INTERNATIONAL PROJECTIONIST

FEBRUARY 1951

VOLUME 26 • NUMBER 2

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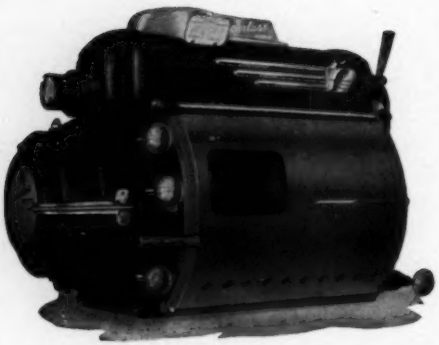

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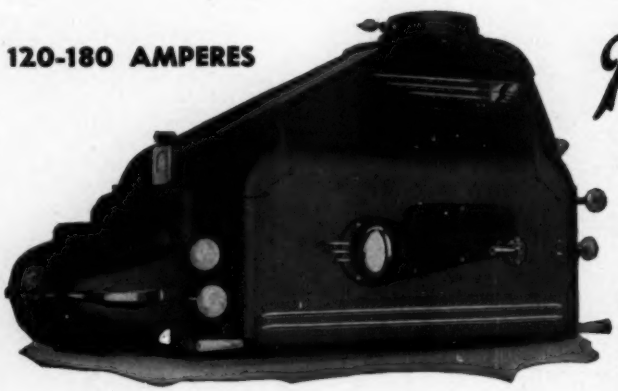

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HENRY B. SELLWOOD, *Editor*

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MONTHLY CHAT

GOOD news for projectionists, and for laboratory and exchange workers as well, issued from Eastman Kodak Company recently in the form of a notification that the problem of proper identification of nitrate and safety film, the topic of numerous complaints from the field, has been given long and serious thought and that a new system of identification has been adopted. These data have not yet been released by Eastman, thus a detailed report thereon will have to await an official nod from Rochester.

It was generally agreed in advance that the gradual replacement of nitrate prints with safety stock would prove more than a bit troublesome, and to this end Eastman spared no effort or expense (ably abetted by IP, if we must say so) to get precise operating instructions into the hands of thousands of projectionists. Of paramount importance, of course, was a means for quick identification of both types of prints.

A safe and simple method for identifying prints is not as easy as it might seem. Edge-marking of prints with the words "NITRATE FILM" and "SAFETY FILM" was adequate so long as only nitrate film was used for professional 35-mm theater films. The rub developed when both types of prints were circulating side by side, caused mainly by printing through from a safety negative onto a nitrate print, or *vice versa*. It soon became obvious that the existing system of identification just wouldn't do; and jittery projectionists were always fearful that a given print handled in approved fashion would come apart at the seams while in transit through the projector.

Many observers wondered why the exclusive use by projectionists of "all-purpose" film cement would not banish the bugaboo of splices coming apart, and they proceeded to demonstrate *in the laboratory* how simple the splicing process was. So far, so good; but we know that this "simple" lab process just didn't do the trick in the field. It could be that the manufacturers of all-purpose cements, badgered by mounting complaints, started to experiment with their formulas and thus further complicated matters.

Whatever the reason for the existing state of affairs, it would seem that Eastman has finally evolved a method which will go far to end the many difficulties experienced thus far in handling both types of stock. Once projectionists are reassured as to the proper identification of a given print—as seems likely under the proposed plan—they can banish their jitters and proceed in normal fashion. Maybe the makers of film cement will also find the going easier.

Eastman is to be congratulated for meeting a difficult problem head-on, without quibbling or evasion. Full details herein when they are available.

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"THERE'S A BRANCH NEAR YOU"

VOLUME XXVI FEBRUARY 1951 NUMBER 2

Optics of the Projection Arclamp

By ROBERT A. MITCHELL

NOTEWORTHY advances have been made in projection lighting in recent years. First there was the Beck "high-intensity" arc. Higher powered lamps have been developed for motion picture applications; and improved burner construction has resulted in rotating-positive mirror lamps which make earlier attempts—notably the old "Hi-Lo" —seem very crude, indeed.

Very important, also, has been the successful production of automatic focus controls which make possible unprecedented accuracy in the positioning of the positive crater without the continued intervention of the projectionist.

There is, however, a dark side to this bright and shining cloud. The fall-off in screen-illumination uniformity which marked the transition from L-I to H-I projection about two decades ago remains a serious defect in projection quality.

The arclamp mirrors which are standard equipment at the present time are elliptical mirrors designed and applied according to a definite theory which has held sway ever since the inception of reflector lamps for projection lighting. This sacrosanct (?) theory demands that:

Standard Reflector Practice

1. The geometric focus (crater-mirror distance) and the working distance (mirror-aperture distance) shall be such that the image of the crater at the aperture shall be only a little larger than the aperture opening.
2. A reasonably true optical image of the crater shall be reflected onto the aperture by making the mirror a concave ellipsoid with the crater at one "focus" and the center of the aperture opening at the other "focus."

Figure 1 shows what all this means. The cross-section of the mirror is a curve which, when continued, forms a closed oval figure called an *ellipse*. The imaginary ellipse is marked out on the drawing by the heavy curved line.

The Points of Foci

Now, every ellipse has inside it two definite points called *foci*. The sum of the distances from the two foci to any point on the ellipse is always the same —this is the unique property of the ellipse.

Condition (2) aforementioned is fulfilled by having the positive crater at one focus and the aperture at the other, as stated. This is shown in Fig. 1. Condition (1) is fulfilled by taking into consideration the diameter of the positive crater and selecting the proper relation between the geometric focus and the working distance.

When reflector arcs were first made, this simple optical theory worked like a charm. By having a nearly perfect image of the crater mirrored onto the aperture, the shortest possible geometric focus could be used, thus increasing the "solid angle" of light picked up by the mirror.

Of course, the image of the crater on the aperture — the "spot" — was never really *perfect*, as small unavoidable humps and hollows in the mirror scattered the light to a certain extent. This was a good thing from the standpoint of uniform screen illumination, however.

Mechanics of L-I Operation

The L-I mirror lamp worked so well because the soft core of the positive carbon caused the middle of the crater to be somewhat less luminous than the outer zones. The inevitable tiny humps

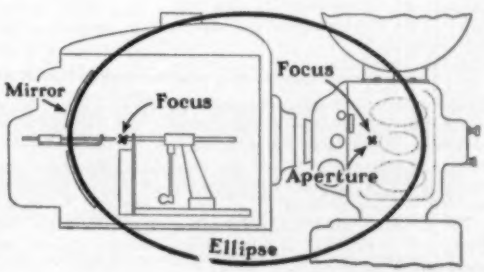

FIGURE 1.

The curved surface of an elliptical mirror is produced in theory by rotating an ellipse around its major axis. Ordinarily, the crater of the positive carbon is placed at one focus of the ellipse, and the projector aperture at the other.

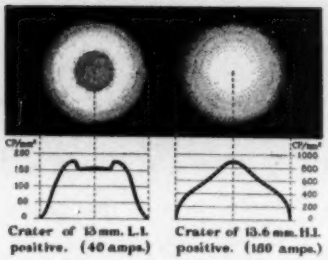

FIG. 2. Brilliancy distribution in low- and high-intensity arc craters.

and hollows in the mirror smoothed the light out to give the effect of a crater of perfectly uniform brilliancy all over its surface. Moreover, if in certain cases the spot was actually a trifle brighter at its edges than in its center, the "vignetting effect" of the early small-diameter projection lenses was effectively neutralized. Low-intensity lighting was admittedly yellowish and dim, but it at least illuminated the picture uniformly.

Figure 2 shows the appearance of the positive crater of both a 13-mm L-I carbon burning at 40 amps. and a 13.6-mm H-I carbon burning at about 150 amps. The graphs underneath the drawings indicate the actual luminosity of the various regions of these craters in candle-power per square millimeter.

Note that the H-I crater has "hot-spot" luminosity characteristics—the center is much brighter than the edge zones. *These characteristics are responsible for all our light-distribution difficulties with the H-I arc!*

Naturally, we have no way to make the H-I crater uniformly brilliant. The ball of luminous vapor is, by the nature of things, brightest at its greatest thickness—the central region of the ball. To do away with this luminous ball would be to destroy the H-I effect. The L-I crater had no such ball of brilliant gas, but depended only on the incandescence of white-hot carbon for its comparatively feeble light.

Mirror Characteristics Control

Obviously, any changes aimed at improving the light-distribution characteristics of the H-I lamp must be made in the mirror.

As an experiment, we may try out mirrors of different curvatures in a high-intensity lamp to see what improvement, if any, can be egected in the uniformity of screen illumination. We shall select mirrors having approximately the same overall focal length in order to keep the working distance constant.

The so-called "spherical" mirror is a good one to begin with. If it fails to improve screen illumination, it at least may indicate the failings of the orthodox elliptical mirrors.

A spherical mirror is, as its name implies, the concave section of a perfect sphere. By using such a mirror, the ellipse shown in Fig. 1 becomes a circle. Now, a circle has only one "focus," and this coincides with the center of the circle. Naturally, the arc and aperture cannot be placed together at the same point, so a compromise is made by having the center of the circle between the crater and the aperture, leaving the working distance practically unaltered.

The results are manifestly disappointing. The sharpest "spot" we are able to obtain at the aperture looks like *A* in Fig. 3; and the resulting screen illumination, illustrated in the right-hand panel, has such a pronounced fadeaway that the sides and corners of the picture are barely discernible. This is "hot-spot projection" at its worst! And all of the light which does not pass through the aperture, but which splays out over the cooling plate, is utterly wasted, and serves only to make the projector mechanism uncomfortably hot.

'Why' of Spherical Aberration

What is the matter with the spherical type of mirror? All projectionists know the answer—an optical defect known as *spherical aberration*. This aberration stretches the crater image out along the optical axis in highly distorted form. Accordingly, no definite focal plane exists with this type of mirror, and the formation of a definite spot is impossible.

The specific reason for this unhappy state of affairs is that the outer zones of the mirror "curve in" too much, forming an image of the crater behind the aperture; while the central zones do not have enough curvature, and thus form an image somewhat beyond the aperture. The resultant poor light distribution and wasteful splaying of light all over the back of the mechanism cannot be avoided with this unsatisfactory type of mirror unless a Schmidt lens is used in conjunction with it—something we had rather not bother with.

Spherical mirrors are never used in projection except in Mazda lamphouses. They serve in this application because the filament of the bulb and the superposed image of the filament both lie in the single focal plane of the spherical mirror.

The Elliptical Mirror

B in Fig. 3 illustrates the type of spot and quality of screen illumination obtained with the orthodox elliptical mirror adjusted for maximum efficiency. The spot is larger than would seem absolutely necessary, but this is because only the brighter central areas of the crater image are utilized for illuminating the picture.

If the spot were made smaller (requiring a mirror of longer focal length), the corners and edges of the picture would be lost in darkness. As it is, the side-to-center distribution of light on the screen is only 55 to 80% when the standard elliptical mirror is used with the H-I arc. Due to the fact that the crater of this arc is a "hot-spot" crater, considerable fadeaway of screen illumination is produced even though the elliptical mirror is free from spherical aberration when arc and aperture occupy the foci of the imaginary ellipse.

Uniformity of screen light could be improved when the ordinary elliptical mirror is used by having an oversized spot (requireing a mirror of shorter focal length than is customary). But this expedient is a poor one, as all light which does not pass through the aperture is wasted.

Here we are at a "dead end," apparently. Even by eliminating all spherical aberration we are unable to obtain absolutely uniform screen illumination! Nevertheless, there is no reason to despair: several other types of mirrors are waiting to be given a trial.

'Antispherical' Aberration

Let us now try a mirror which produces the *exact opposite* of spherical aberration. This new kind of optical distortion may be called *antispherical* aberration; and the mirror which produces it, an *apospherical* mirror. Opticians may prefer other terms, but mere nomenclature cannot change the essential character of the mirror.

The apospherical mirror may be elliptical in form, or parabolic, or even hyperbolic, depending on the luminosity gradient of arc crater which serves as the source of light. We are primarily interested in two requirements: perfectly uniform screen illumination, and a mini-

(*Continued on page* 28)

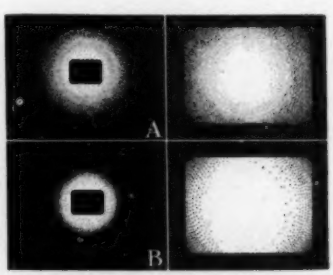

FIG. 3. The aperture "spot" and resulting screen illumination produced by *A* a spherical mirror, and *B* an ordinary elliptical mirror. The light-scattering effect of spherical aberration is seen in *A;* and the effect of non-uniform brilliancy distribution in the H-I crater in *B*.

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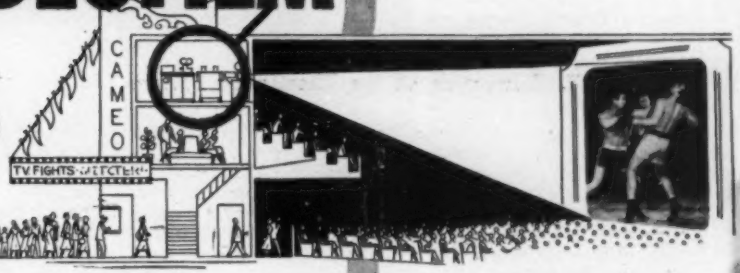

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III. Formation of the Theater Tv Picture

THERE is one basic difference between the projection of motion pictures from film and from a television signal, as was pointed out in the first article of this series. The film picture is complete. Each frame consists of many thousands of fine grains of silver, so arranged that they form the dark portions of the picture. Each of these grains may be called an element of the picture.

The television picture, on the other hand, is formed as it is transmitted from the camera. Since a radio or wire channel can transmit only one bit of information at a time, it is necessary to completely go over the whole picture, part by part, and transmit information as to the relative brightness of each part to the receiver. The receiver must then build up a picture from the information which it receives from the transmitter.

Three Requisites for Process

Three things are necessary for this process. The receiver and the camera must both "scan" the picture in exactly the same manner, and they must do so at exactly the same time, in order to have the elements of picture formed by the receiver in the proper places to correspond with the original picture. Also, the receiver must produce brightness proportional to that of the transmitted picture at all points.

Practically, the picture is scanned in much the same manner as a person's eye scans a page of print. The electron beams in the camera tube and in the Kinescope are moved simultaneously from left to right across the top of the picture, then returned to the left side of the picture, but slightly below their original position, and again moved across the picture from left to right. The process is then repeated, with the beams starting out from the left side each time slightly lower than the preceeding time, until they reach the bottom of the picture. Then they return to the top, and start the process over again.

As with a person's eye, which effectively sees nothing while returning from right to left across the page, and from bottom to top, the scanning beams in camera and Kinescope are cut off while these beams make their similar returns.

Thirty complete pictures, or frames, are produced each second in our television system. However, it is desirable to reduce the flicker which would be produced by such a low picture rate. Increasing the number of frames per second would do this, but would complicate the transmission circuits in a cable system, and would occupy too many channels in a radio system. Therefore, an expedient equivalent to the flicker blade on a motion picture projector is utilized.

Two 'Fields' Per Frame

The frame is made up of two "fields," each of 1/60 second duration. This is accomplished by making the scanning beam travel over alternate lines as it goes down the picture. The first time it scans lines 1, 3, 5, 7, *etc.*, forming the first field, and after reaching the bottom of the picture it returns to the top and scans lines 2, 4, 6, 8, *etc.*, thus completing the picture after the second field. This method of scanning reduces the picture flicker below visibility.

In order to obtain and maintain absolute synchronism between the scanning beams in the camera and receiver tubes, a "trip," or synchronizing, signal is sent while the scanning beam is returning from the right side of the picture to the left, and while it is returning from the bottom of the picture to the top. Because the beam is cut off during these times, the synchronizing signal does not produce any interference in the picture.

As both beams are started from the left side of the picture, and from the top, at the same time, they will both be in the same position on the screen at all times, and therefore the receiver will produce its brightness changes at the same point as they are scanned in the camera, thus producing on the Kinescope screen a picture identical to that in the camera.

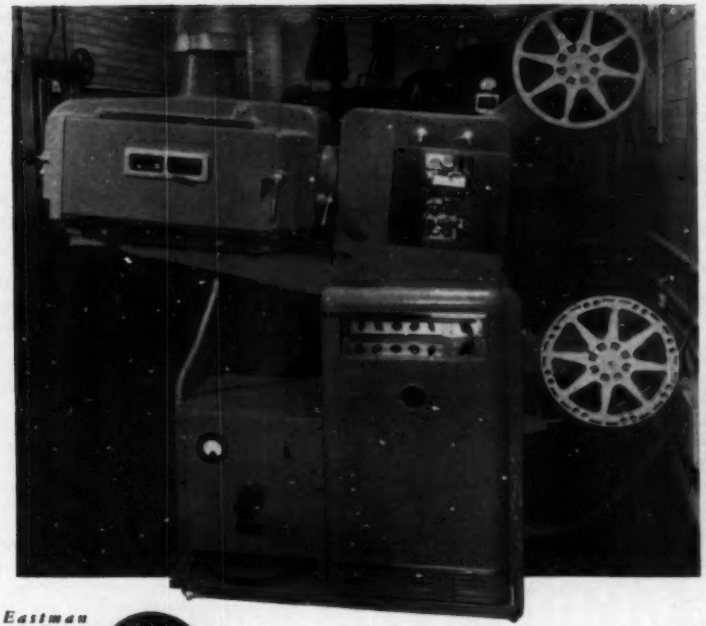
In order to produce a picture on a large theatre screen, the image on the face of the Kinescope must be transferred to the screen. This is essentially the same thing that is done with a frame of motion picture film. Basically, this means that at every point on the theatre screen there must be produced an amount of light which is proportional to the amount which exists at the corresponding point on the film image, or, in the case of the television projector, the image on the face of the Kinescope.

In the film projector, light from the arclamp is passed through the film. After passing through the film, it goes into the projection lens. The lens has the property of bending light from any point on the film to a corresponding point on the screen. This is true regardless of the point on the lens surface where the light from any one point on the film image strikes it. However, the best projection lenses are not good enough to be used in a television projector, where the amount of light from the picture on the Kinescop screen is much smaller than that produced by an arclamp, as they would not catch enough light from the Kinescope image to produce a well-illuminated screen picture.

The RCA Optical System

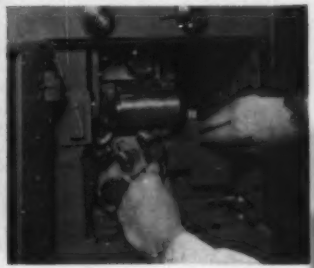
The RCA PT-100 theatre television projector utilizes a reflection optical system which operates in a very similar manner to the mirror of a reflector arclamp. The Kinescope face, with its picture, occupies the same relative position as the positive carbon crater in such a lamp. The mirror is 26 inches in diameter. Because it is so much larger in diameter than the largest projection lens, and only about one foot from the Kinescope face, it can intercept much more light than the lens could. Thus, the amount of light which is reflected to the screen is greatly increased.

Light from any point on the Kinescope face will reach some part of the mirror. From there it is reflected to the screen. Light from the bottom of the Kinescope face will be reflected to the top of the screen; light from the top of the Kinescope face will be reflected to the bottom of the screen; therefore, the picture on

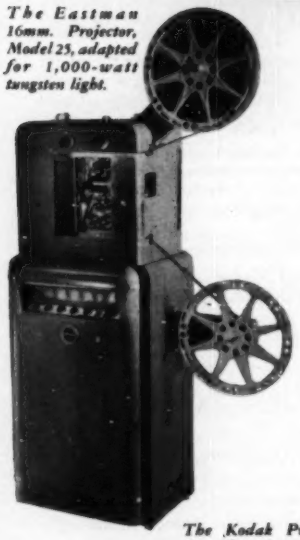


Left, the Eastman 16mm. Projector, Model 25, brings 16mm. projection to the professional level. Shown here, adapted for arc illumination, permanently installed alongside 35mm. equipment.

Below, working parts of the film movement mechanism are in constant view of the operator . . . readily accessible for threading and cleaning.



The Eastman 16mm. Projector, Model 25, adapted for 1,000-watt tungsten light.



The Kodak Projection Ektar Lens, in a choice of four focal lengths, insures superior screen image.

For Professional Quality Sound Projection from 16mm. Film

The Eastman 16mm. Projector, Model 25

This projection instrument—built to a new design concept—eliminates the three major obstacles to theatrical quality 16mm. sound projection . . . excessive wear and high maintenance cost; low signal-to-noise ratio; and excessive flutter.

A major cause of excessive wear and poor quality sound is the constant transfer of shock forces generated in the film pulldown mechanism to other parts of the system. In the Eastman 16mm. Projector, Model 25, the intermittent (film advance mechanism) is completely isolated and independently driven by its own 1440 r.p.m. synchronous motor. Thus, shock forces are sealed off from the rest of the instrument. The sprocket-shutter system is driven by its own 1800 r.p.m. synchronous motor. Exact phasing between the two systems is accomplished by specially designed synchromesh gears. In addition, the take-up spindle, rewind spindle, and blower are driven by separate motors.

A highly corrected microscope objective, adjustable for optimum sound quality from any type of 16mm. sound film, permits reproduction of variable area or variable density 16mm. sound tracks at extremely low distortion and a maximum signal-to-noise ratio.

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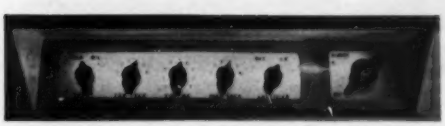

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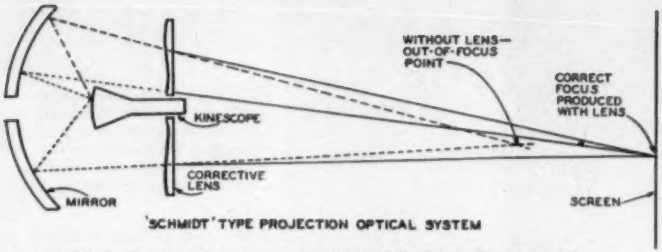

FIG. 1. The optical system for the RCA PT-100 Theater Television system.

the Kinescope screen must be produced upside down.

Light from the right and left sides of the Kinescope picture will similarly be reflected to the respective opposite sides of the screen, reversing the picture from left to right. The picture on the Kinescope face is therefore produced reversed from left to right. Thus, in spite of the use of a mirror instead of a lens, the picture on the Kinescope face is reversed from top to bottom and from left to right during projection, the same as a film picture projected through a lens.

A mirror has another advantage over a lens. Because the light which it reflects does not go through any glass (the mirror is coated with aluminum on its *front* side) there is theoretically no chromatic aberration—that is, light of all colors is reflected at the same angle. (In a lens, where the light goes through the glass, different colors are bent at different angles: this requires the use of different kinds of glass to obtain partial correction and nearly correct focus of different colors.)

Spherical Aberration Correction

There is one fault which is common to both mirrors and lenses—spherical aberration. It results in bending the light which strikes near the edge of the lens or mirror at a greater angle than the light which strikes nearer the center. Again, reducing this effect in a lens requires the use of several individual lenses. With a mirror, however, a single, thin lens will correct the condition.

This lens has a very special and peculiar shape, as depicted in Fig. 1. The dotted lines show the path of the light as it travels to and leaves the mirror (it would continue to follow these lines if the lens were removed); the solid lines show it as it leaves the lens. Notice how all solid lines come together, or focus, at the same distance from the mirror, after the corrective lens has done its work, whereas the dotted lines focus at different distances from the mirror, as shown, if the lens were not used. Because this lens is very "weak," it does not introduce appreciable distortion of its own.

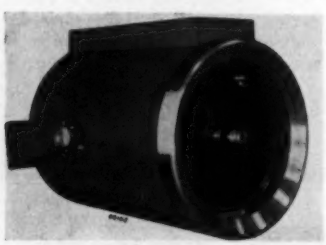

FIG. 2. Projection unit for RCA PT-100 system, usually mounted on the front of first balcony.

Kinescope Light Controlling

Light from any one point on the Kinescope face may strike the mirror at any point; however, as in the case of the projection lens, it will be bent to reach the same point on the screen. The same thing is true for light from any other point on the Kinescope face: light from it will all reach the same point on the screen, regardless of where it strikes the mirror. This second point, of course, will be at a different point on the screen from the first one. The amount of light at any point on the screen will be proportional to the amount produced at the corresponding point on the Kinescope face, therefore the picture on the Kinescope screen will be reproduced on the theatre screen.

Designed for 'Average' Throw

The curvature on the Kinescope face, the mirror, and the corrective lens are all dependent on the distance from the projector to the screen, or the "throw" distance. Therefore, it is necessary to assume an average throw distance and design the optical system for proper focus at this distance. The actual working distance may be increased or decreased above or below this design value by about 10% without appreciable loss of picture detail.

This somewhat limits the position which the optical barrel must occupy in a given theatre; usually, however, a position may be found on the standee rail, balcony front, or other suitable point, so that the throw will be within the acceptable limits. As no operating controls are located at the optical barrel, access to this unit during showtime is not required during normal operation. Fig. 2 shows the RCA PT-100 theatre Tv projection unit.

To further increase the light from the screen, it is customary to use a special screen which reflects practically all light from the projector to the seating area.

[Note: The fourth article of this series will point out certain equipment features required by the nature of theater TV projectors, and wherein they differ from non-theatrical TV receivers.]

Projectionist Examination Questions

Based on Examinations by Leading U. S. Municipalities

1. What will cause a wire terminal to heat up?
2. Show by diagram two arcs connected to a 110-220 volt, two-wire circuit.
3. Show by diagram two arcs connected to a 110-volt, two-wire circuit.
4. What necessary appliances does the 110-volt D.C. arc pass through from the main switch to the arc?
5. Show by diagram a balanced load of two arcs, two meters, and two rheostats on a three-wire, 110-220 volt line.
6. Explain "voltage drop."
7. Having an alternator with 12 poles and a speed of 1200 R.P.M. and a frequency of 60 cycles, at what speed must a synchronous motor travel to be in step with it if it has 8 poles?
8. If you had a 220-volt transformer with 50 amperes on the primary side and 110 volts on the secondary side, what amperage would you have on the secondary side, presuming that it had an efficiency of 90%?
9. Does the resistance of an ordinary wire conductor change if it is forced to carry current beyond its normal rated capacity?
10. How would you determine the size of the wire to be brought into a new theater to supply the projection and house lighting circuits?
11. How would you connect two transformers in series?
12. What is the resistance of a wire having a 3½-volt drop when carrying 45 amperes?

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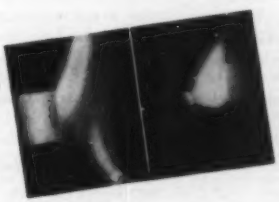

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The Strong Trouper High Intensity Arc Spotlamp (eight of which are used by "Holiday on Ice") has been widely adopted by not only ice shows but also theatres, night clubs, circuses, coliseums, schools, arenas, TV studios, and stadiums.

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Motion Picture and Television Screens†

By FRANCE B. BERGER
General Precision Laboratory

Two fundamental factors, brightness gain and reflectance or transmittance, determine the suitability of a screen material in any particular application. High brightness gain, which necessarily implies a narrow viewing angle, may be desirable in one application but not in another. The reflectance or transmittance of the screen material is a measure of the light efficiency. Comparative figures for several commonly used screen materials are presented. Both front and rear projection screens are considered. The figures are considered to be within 5%, reasonable agreement with the few published figures available.

AT VARIOUS times in the past we have needed quantitative information regarding particular screen materials used in motion picture and television projection. A search of the literature on the subject revealed very few published figures and very little uniformity in the nature of the figures chosen for presentation.

The lack of uniformity may be attributed to the fact that there are several systems of photometric units in common use, and, further, that certain photometric terms have been defined differently by various authors. The necessity for subsequent interpretation of published data detracts from the value of the information.

The brightness of a screen as viewed by an observer depends not only upon the illumination falling on the screen but also upon the directional properties of the screen. Observers at different positions in the audience may see different brightness levels, depending upon the angle from which they view the screen.

The screen's performance in this respect is governed by certain fundamental optical properties of the screen material. Before these properties can be discussed, though, optical terms which apply alike to all projection screens should be defined. Following the definitions, the basic optical characteristics will be described in as non-mathematical a manner as possible. An exact treatment requires a mathematical approach, but since the mathematics may often obscure the physical concepts under discussion, they are relegated to appendixes.

† J. Soc. Mot. Pict. and Tv Eng., August, 1950, p. 131.

General Screen Characteristics

Of the total incident light projected onto a screen, some is transmitted through the screen, some is reflected or scattered from the screen, and the rest is absorbed by the screen. The fraction of the total incident light that passes through the screen is called the *transmission factor* or the *transmittance* of the screen. The fraction which is reflected from the screen is called the *reflection factor* or the *reflectance*. The fraction which is neither transmitted nor reflected is called the *absorptance*.

These three quantities are often expressed as percentages, their sum being, of course, 100%. For a front projection screen a large reflectance is desirable, and the transmittance is generally small. For a rear projection screen, large transmittance and small reflectance are desirable. The absorptance should be small in either case.

The color of a screen depends upon the spectral composition of the light projected onto the screen, and also upon the reflecting or transmitting properties of the screen material itself. Strictly speaking, the transmittance, the reflectance and the absorptance of a screen depend upon the wavelength of the incident light.

For most purposes a projection screen should be "white," that is, it should reflect or transmit to the same extent light of all visible wavelengths. For the present purpose we shall assume that we are dealing with white light and with white screens.

Specular, Diffuse Materiels

A screen material may be characterized as either specular or diffuse. The light transmitted by a sheet of glass, which passes through unchanged in its direction of propagation, is an example of *regular transmission*. The light reflected by a mirror leaves at a definite angle with relation to the angle of the incident light. Such reflection is referred to as *specular*. For convenience the term *specular* will be used in referring to either regular transmission or specular reflection.

In contrast to specular effects, a beam of light falling on a blotter is reflected from the illuminated spot in all directions. A beam of light passing through a sheet of ground glass emerges in all directions. Such reflection and transmission are commonly referred to as *diffuse*. Diffusely transmitted or diffusely reflected light is referred to as *scattered* light.

Both the transmittance and the reflectance of a material can be separated into two parts, the specular and the diffuse. When this distinction between specular and diffuse transmittance or reflectance is not made, the term *total transmittance* or *total reflectance* may be used to so indicate. Most materials that are suitable for projection screens have small specular coefficients, and one simply refers to the "transmittance" or "reflectance" of the screen.

Polar Distribution Data

The relative amount, or intensity, of light scattered in the various directions is conveniently represented by a polar distribution diagram. Different screens have different scattering properties and are, therefore, represented by different distribution diagrams. A distribution diagram such as in Fig. 1A characterizes a diffusely-transmitting screen. A screen material having appreciable specular trans-

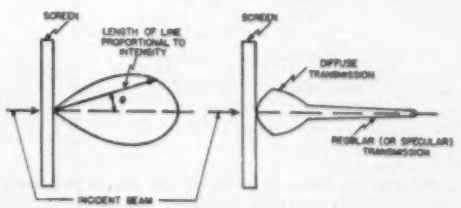

FIGURE 1

Polar intensity distribution diagrams of rear projection screens: *A*, diffusely transmitting screen; *B*, screen exhibiting regular (or speculer) as well as diffuse transmission.

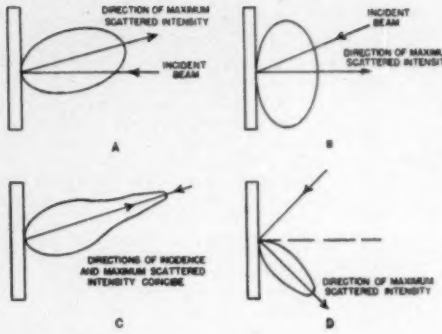

FIGURE 2

Some of the possible types of intensity distributions for front projection screens: *A*, medium brightness gain screen with pattern asymmetrical with respect to the normal; *B*, diffusing screen with brightness gain less than unity; *C*, behavior typical of beaded screens; *D*, high brightness gain screen exhibiting marked specular behavior characteristics.

mission in addition to diffuse transmission is represented by Fig. 1B.

Strictly speaking, polar distribution "diagrams" must be three-dimensional diagrams and the distribution "curves" are really surfaces. If the distribution is symmetrical about the normal to the surface, a simple plane diagram completely describes the directional scattering properties of the screen. If the distribution is unsymmetrical, and many practical screens have such unsymmetrical directional characteristics, the distribution is commonly represented by two plane diagrams: one for the distribution in a vertical plane, the other for the distribution in a horizontal plane.

In the examples cited, it has been tacitly assumed that the maximum intensity of the scattered light is observed in the direction normal to the screen surface. This may often be the case, but is by no means always true. In particular, if the direction of illumination is oblique to the screen surface, the maximum illumination is often observed to be in a direction other than normal to the screen surface. Certain possible situations are represented by the diagrams in Fig. 2, which pertain to front-projection screens.

Choice of Screen Material

The choice of a screen for use in a given situation depends on how the audience is distributed about the screen. The screen should direct as much light as possible toward the audience, and as little light as possible in other directions. A screen which is "tailored" to the audience will make the most efficient use of the available light from the screen.

It is evident that the vertical and the horizontal distribution diagrams of the screen need not be the same. A screen which confines the scattered light to the minimum vertical and horizontal angles consistent with the particular requirements will have maximum usable brightness gain. A screen with a lower brightness gain will not utilize the available light to the greatest advantage.

A screen which appears equally bright to all observers within the intended region of coverage of the screen and which has zero brightness to observers situated outside this region cannot be achieved in practice. Screen materials can, however, be chosen to approximate this condition reasonably well.

Parameters which are useful in making such a choice are the horizontal and vertical angles of coverage. The brightness gain of a screen is related to these angles of coverage, usually defined as the angles between the directions in which the screen has half its maximum brightness.

Incident Light Characteristics

It is frequently assumed that the light incident on the screen comes from a single well-defined direction. This assumption should, however, be used with care. In practice, the light incident on any point of the screen consists of a cone of rays coming from the projection lens aperture and converging at the point on the screen. Further, the rays falling on the edges and corners of the screen have a different angle of incidence than the rays at the center.

In motion picture projection, the cone of rays converging at any point on the screen is very small, and the rays to opposite corners of the picture make a rather small angle with each other. Moreover, low brightness gain (wide angle) screens which closely approximate Lambert scatterers are generally used. Therefore, in motion picture practice, the assumption is valid.

In television projection, on the other hand, the angles involved are quite large and high-brightness-gain screens are generally employed. The range of angles of incidence of the light rays at the screen may be comparable to or larger than the

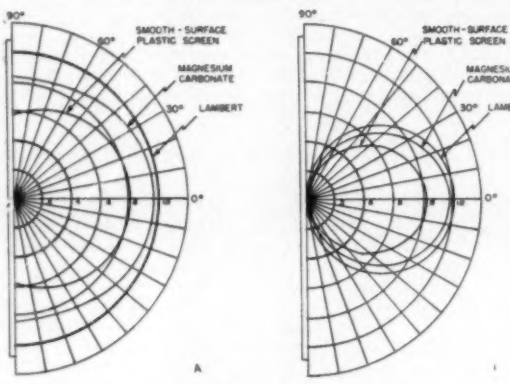

FIGURE 4

Brightness and intensity patterns for a "perfect" screen and the smooth surface plastic screen. On the brightness diagram, *A*, the radial scale gives foot-Lamberts per foot-candle; on the intensity diagram, *B*, radial scale gives candles per π square feet of screen area per foot-candle of illumination.

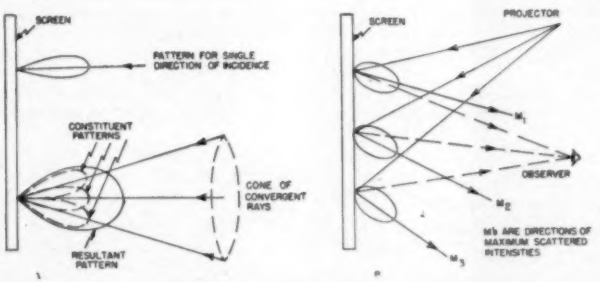

FIG. 3

***A* diagrams the broadening of the intensity diagram that results when light is incident over an appreciable range of angles; *B* illustrates the variation in relative brightness accompanying a variation in angle of incidence across the screen.**

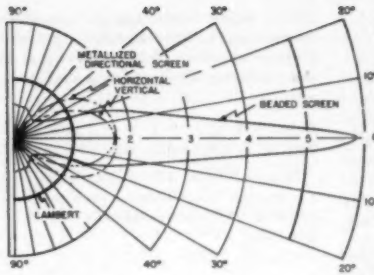

FIGURE 5

Brightness patterns for a typical beaded screen and for a metallized screen. The pattern for a "perfect" screen is shown for comparison. The radial scale is graduated in foot-Lamberts per foot-candle of illumination.

angular width of the distribution diagram. When the incident convergent cone of rays is large, the effective distribution diagrams are broadened and the effective brightness gain is lowered, as shown in Fig. 3A.

When the angle of incidence changes sufficiently over the screen area, the distribution diagram differs correspondingly for different regions of the screen. This generally will result in nonuniform brightness over the screen area, the effect becoming more noticeable at high brightness gain figures and at large oblique viewing angles. Curved screens, auxiliary optical elements such as a Fresnel lens, non-homogeneous screens, or other innovations may offer advantages in these cases.

Table I gives the results of laboratory measurement on a number of screens and of several miscellaneous materials. Some of the materials were measured by the intensity method and others were measured by both the intensity and the brightness methods. All data presented refer to measurements made with incident illumination normal to the screen surface. All of the screens are homogeneous, except the ribbed plastic screen with Fresnel lens; measurements on the latter pertain to the central region only. Some of the laboratory measurements are presented in Figs. 4 and 5.

List Requisites for Survival of the Motion Picture Theater

"Although home Tv seems to be acquiring a mass audience," Benjamin Schlanger and William Hoffberg, theater architectural and engineering consultants, told the recent SMPTE meeting, (Fall, 1950, convention at Lake Placid, N. Y.) "there will always be a motion picture theater and theater Tv audience consisting of those who wish to see entertainment not available in other mediums; those who wish to avoid advertising intrusions; those desiring a respite from home entertainment; those satisfying their gregarious instincts, and those who prefer the dramatic impact of the large theater screen cinematography."

New and existing theaters which offer the seating, air conditioning, projection and sound transmission comforts now available, and which add to these the increased screen image, the luminous screen field, the increased flexibility and scope of motion picture cinematography, the feelings of intimacy within the auditorium, and stereoscopy of sound and vision, should survive within the forests of home antennae, they concluded.

TABLE I. *Characteristics of Representative Screen Surfaces*

Screen	Brightness Gain	Reflectance	Transmittance	Effective Brightness Gain
Miscellaneous Materials				
Perfect screen	1.0	100	100	1.0
Magnesium carbonate	1.1	88	—	0.97
Traceolene paper	13.6	—	87	11.8
Opal glass	1.0	—	48	0.48
White blotting paper	1.4	61	—	0.85
Brushed aluminum	4.5	65	—	2.9
Motion Picture Screens				
Smooth-surface plastic (perforated)	1.15	72	—	0.83
Beaded	16.4	35	—	5.7
Nylon cloth	1.2	49	—	0.6
Metallized directional (perforated)	2.5	70	—	1.8
Glass cloth	1.7	47	—	0.8
Commercial Television Screens				
Translucent plastic #1	12.	—	54	6.5
Translucent plastic #2	6.2	—	62	3.9
Diffusing cloth	4.2	—	47	2.0
Diffusing glass	5.1	—	70	3.6
Ribbed glass	7.0	—	49	3.2
Ribbed plastic with Fresnel lens	8.0	—	43	3.2
Metal beaded	7.5	61	—	4.6

New Optical Theory Described

A new mathematical theory expected to be an aid to lens designers was described recently by Dr. Max Herzberger at a physical colloquium at Syracuse University. Dr. Herzberger is a scientist at Kodak Research Laboratories. His new formula is said to provide a complete solution for image errors in lens systems.

Exact Computation Possible

Basically, the theory reduces the various possible errors for each light ray passing through a lens system to two errors which can be computed exactly. When one of these errors is eliminated, a symmetrical image is formed. Removal of both errors gives a sharp image. The theory is a generalization of the Seidel image-error theory. It will be valuable in the design and evaluation of lenses because it will allow a lens designer to learn the limitations of a new lens system while it is still on the drawing board, Dr. Herzberger said.

Dr. Herzberger is the author of *Strahlenoptik* (Ray Optics), published in Berlin in 1932, and of 150 papers in the field of geometrical optics and mathematics. He holds several patents dealing with optics and photography.

More Stringent Copper Restrictions

March 1 is the effective date for the stringent copper conservation order issued recently by the NPA. The order permits the use of copper where it serves a "functional" purpose and where no practical substitute is available. It will not be used where it is non-functional—that is, for ornaments or decorative purposes. Previous NPA actions on copper, providing for use of a certain percentage of the total used in previous years, remain in force.

Netter Heads Altec Service Sales

L. D. Netter, Jr., has been appointed general sales manager for Altec Service Corp. In addition to his responsibilities to the service company, Netter will oversee product sales made by the company in its role as manufacturer's sales agent for Altec Lansing Corp. Netter joined Altec in Nov., 1947.

Maintenance and Servicing of Motors

By ROBERT A. MITCHELL

The fourth and concluding installment of a series of articles on the types of motors used in the projection field, with special emphasis upon the recognition and correction of various troubles encountered.

CHART II. POLYPHASE INDUCTION MOTORS

1. BEARINGS TOO HOT

Trouble: Bearing dry. *Cause*: Insufficient lubrication; oil rings not working. *Remedy*: Clean bearings with kerosene, flush with oil, then refill with fresh oil or grease of the proper type. Check action of oil rings.

Trouble: Bearing dirty. *Cause*: Dust or dirt in oil or grease. *Remedy*: Wash out oil or grease reservoir with kerosene and refill with the proper lubricant.

Trouble: Tight bearing. *Cause*: Provide clean lubricant, replace rings with rings not too tight. (If ring sticks or runs slowly, bevel it with a fine file.) Polish shaft with emery paper, or replace bearing.

Trouble: Bearing binding. *Cause*: Sprung shaft. *Remedy*: True the shaft in a lathe and replace the bearings.

Trouble: Loose bearing. *Cause*: Vibration and wear. *Remedy*: Tighten screws which hold bearing. Replace bearing.

2. ENTIRE FRAME TOO HOT

Trouble: Transference of heat from bearings, rotor, or stator. *Causes and Remedies*: See directly following, and Causes and Remedies under Symptoms 1, 3, 4, 5, 6, and 7.

Trouble: Heat transferred from rotor or stator. *Cause*: Motor overloaded. *Remedy*: Test each phase with an ammeter, and if readings are abnormally high, reduce the load or obtain more powerful motor.

Trouble: Motor running single-phase. *Cause*: One fuse blown, or one overload relay out of order. *Remedy*: Replace fuse or adjust relay and take ammeter readings of each phase.

3. SMOKE ISSUES FROM ROTOR WINDINGS; WEDGES OVER CERTAIN COILS ARE CHARRED

Trouble: Rotor not centered in stator. *Cause*: Bearings worn. *Remedy*: If noticed before coils are damaged, renewal of the bearings and inserting new wedges will correct the fault; otherwise coils will need to be replaced.

4. EVERY THIRD COIL IN A 3-PHASE MOTOR STATOR IS HOTTER THAN ADJACENT COILS

Trouble: Insufficient impedance in phase which is hottest, causing unbalanced currents in phases. *Cause*: One or more coils of one phase short-circuited within themselves. *Remedy*: Replace short-circuited coil. (Do *not* jump the coil!)

Trouble: One phase grounded inside motor. *Cause*: Dampness or damage. *Remedy*: Eliminate ground by lifting coil and re-insulating.

5. MOTOR RUNS HOT, AND EXPLOSIONS, SOMETIMES ACCOMPANIED BY FIRE, OCCUR IN WINDINGS

Trouble: Temporary ground or short-circuit. *Cause*: Dampness, which allows currents to circulate between coils and between any coil and ground. *Remedy*: Bake rotor and stator until all dampness disappears, then paint all coils with insulating varnish (which needs to be baked) or Glyptol (which dries in air). If coils are punctured, replace with new coils.

6. STATOR COILS OF ONE OR MORE PHASES HOT IN SPOTS, WHILE COOL IN OTHERS

Trouble: Part of windings inoperative. *Cause*: Short circuits between adjacent stator coils. *Remedy*: Replace short-circuited coils, as they will usually be found to be badly burned.

7. MOTOR RUNS, BUT ROTOR HEATS UP WHILE THE STATOR IS COOL

Trouble: Abnormal currents in rotor. *Cause*: Rotor bars loose or grounded; wound rotors short circuited. *Remedy*: Tighten set screws holding rotor bars to short-circuiting rings; replace wound rotors.

8. MOTOR REFUSES TO START, BUT MAKES A HUMMING SOUND

Trouble: Motor tries to run single-phase. *Cause*: One fuse blown, or overload relay out of order. *Remedy*: Replace fuse or adjust relay.

Trouble: Rotor not centered in stator. *Cause*: Bearing worn or out of adjustment. *Remedy*: Center the bearing, and replace worn bearings.

Trouble: Open circuit in stator windings. *Cause*: Coil damaged. *Remedy*: Replace faulty coil.

9. MOTOR ISSUES A PECULIAR SOUND WHEN RUNNING LIGHT, AS IF A HEAVY LOAD WERE THROWN ON PERIODICALLY, WITH A SLIGHT SLACKENING OF SPEED AT THESE INTERVALS

Trouble: Coil connections of one phase reversed. *Cause*: Connected wrongly when repaired. *Remedy*: Connect coil to its proper group, and in correct polarity.

10. MOTOR LOSES POWER AND SPEED WHEN FULLY LOADED

Trouble: Rotor to one side of magnetic center of stator. *Cause*: End play all taken up at one end of shaft; motor out of level; coupling driven too far on shaft if direct coupled. *Remedy*: Readjust end play so that rotor will "float." Level motor. Bring coupling out to restore floating of rotor.

CHART III. SINGLE-PHASE INDUCTION MOTORS

Including Split-Phase, Capacitor, and Repulsion-Induction Types

1. BEARINGS TOO HOT

Trouble: Bearing Dry. *Cause*: Insufficient lubrication; oil rings or wool wick not working. *Remedy*: Wash bearings and wicks in kerosene, flush with oil, then refill with fresh oil or grease of the proper type. Check action of rings.

Trouble: Bearing dirty. *Cause*: Dust or dirt in oil or grease. *Remedy*: Wash out oil or grease reservoir with kerosene and refill with proper lubricant.

Trouble: Tight bearing. *Cause*: Insufficient lubrication, grit in oil, oil rings not working, undersized bearing if bearing has been replaced. *Remedy*: Provide clean lubricant, replace rings with rings not too tight. (If ring sticks or runs slowly, bevel it with a fine file.) Polish shaft with emery paper, or replace bearing.

Trouble: Bearing binding. *Cause*: Sprung shaft. Too much strain on pulley. *Remedy*: True the shaft in a lathe. Shim the bearing with thin pieces of tin as a temporary expedient. Install new bearings.

Trouble: Loose bearing. *Cause*: Vibration and wear. *Remedy*: Tighten set-screws holding bearing. Replace worn bearings.

2. ENTIRE FRAME TOO HOT

Trouble: Transference of heat from bearings, rotor, or stator. *Causes and Remedies*: See directly following, and also Causes and Remedies under Symptoms 1, 3, 4, 5, and 6.

Trouble: Heat transferred from rotor or stator. *Cause*: Motor overloaded. *Remedy*: Lighten load, or use a larger motor.

Trouble: Motor running on starting winding. *Cause*: Frequency too low. Centrifugal switch stuck or capacitor shorted. *Remedy*: Turn motor off immediately to avoid burning up the starting winding! Use proper motor for line frequency, repair centrifugal switch by cleaning, oiling lightly, and operating by hand a few times. Replace capacitor. Inspect stator windings for possible damage.

Trouble: Motor heats up even though load is light, and centrifugal switch and

other auxiliary apparatus are in perfect working order. *Cause*: Rotor not centered in stator. *Remedy*: Replace bearings and align them properly. (There should be an all-around clearance of 0.015 to 0.030 inch between rotor and stator poles.)

3. ONE SECTION OF THE STATOR WINDING HOTTER THAN OTHER PARTS

Trouble: Short-circuited stator winding. *Cause*: Worn or deteriorated insulation; mishandling. *Remedy*: Renew the short-circuited winding.

4. MOTOR RUNS HOT, AND EXPLOSIONS, SOMETIMES ACCOMPANIED BY FIRE, OCCUR IN THE WINDING

Trouble: Temporary ground or short circuit. *Cause*: Dampness, which allows currents to circulate between coils or between any coil and ground. *Remedy*: Bake rotor and stator until all dampness disappears, then paint all coils with insulating varnish (which must be dried by baking in an oven at 115° C., or 239° F.) or Glyptol (which dries in air at room temperature). If coils are punctured, replace with new coils or have the stator rewound.

5. MOTOR RUNS, BUT ROTOR HEATS UP, WHILE STATOR REMAINS REASONABLY COOL

Trouble: Abnormal currents in rotor. *Cause*: Squirrel-cage rotor bars loose. *Remedy*: Tighten set screws holding rotor bars to short-circuiting ring. (Most fractional H.P. motors have bars welded or soldered to the short-circuiting ring, making this trouble impossible.)

6 REPULSION ARMATURE WINDING (ON CERTAIN TYPES OF REPULSION-INDUCTION MOTORS) HEATS UP

Trouble: Brushes not disconnected when motor picks up speed. *Cause*: Centrifugal switch not functioning. *Remedy*: Overhaul switch, oil sparingly, and operate it by hand a few times. Check tension springs.

7. BRUSHES (OF CERTAIN TYPES OF REPULSION-INDUCTION MOTORS) DO NOT LEAVE COMMUTATOR WHEN MOTOR IS NEARLY UP TO NORMAL RUNNING SPEED

Trouble: Governor fails to function. *Cause*: Overload, low voltage, wrong frequency, governor sticking. *Remedy*: Run motor "light" to see if governor functions; decrease load or increase size of motor. Test line voltage; use motor designed for line voltage and frequency. Wipe excess oil from governor, apply kerosene sparingly, loosen springs.

8. BRUSHES ON COMPENSATED WINDING (OF CERTAIN OTHER TYPES OF REPULSION-INDUCTION MOTORS) DO NOT MAKE CONTACT WITH COMMUTATOR WHEN MOTOR IS NEARLY UP TO SPEED

Trouble, Cause and Remedy: See No. 7.

9. ABNORMAL ARCING AT BRUSHES OF REPULSION-INDUCTION MOTORS

Trouble: Short circuit in armature coil. *Cause*: Carbon between commutator bars, insulation burned from leads connecting segments to armature, short circuit in one or more armature coils. *Remedy*: Undercut mica between segments with slotting tool, bevel slightly the edges of the copper bars, and then paint the exposed mica with glossy red enamel of the iron oxide or synthetic type. Securely tape all leads. Rewind or renew armature.

Trouble: Loose contact between the short-circuiting segments and commutator in certain types of repulsion-induction motor. *Cause*: Segments jammed in holders. *Remedy*: Sandpaper the segments and commutator with 00 sandpaper (NOT emery paper!) and see that the short-circuiting segments are not sticking.

Trouble: Loose contact between short-circuiting brushes and commutator in certain other types of repulsion-induction motor. *Cause*: Brushes too short or sticking in holders. *Remedy*: Renew worn brushes. Work brushes in holders until brushes are loose. Sandpaper commutator and brushes.

10. SPEED OF MOTOR FLUCTUATES

Trouble: Centrifugal switch or brush governor cuts in and out frequently. *Cause*: Switch or brush-actuating mechanism not properly adjusted. Low voltage. Poor switch contacts. *Remedy*: Wait for voltage to come up to normal. Adjust tension springs, repair loose connections, clean switch contacts.

Trouble: Line voltage or frequency erratic. *Cause*: Beyond control of operator. *Remedy*: None. This condition usually corrects itself after a few moments.

11. MOTOR FAILS TO START

Trouble: Load too great. *Cause*: Motor too small for load; friction. *Remedy*: Obtain a motor suitable for the load. Examine motor bearings, couplings, and mechanical condition of driven machinery.

Trouble: No current. *Cause*: Blown fuse; line open. *Remedy*: Inspect fuse and replace, if necessary. Test line, repairing any breaks which may be discovered. Test motor leads.

Trouble: Open circuit in stator. *Cause*: Rough usage, or burned coil or connection which may have opened. *Remedy*: By means of a circuit-tester locate the defective coil, which must be replaced. (Do not jump the open coil!)

Trouble: Open circuit in armature. *Cause and Remedy*: See directly above.

Trouble: Rotor rubbing on stator core. *Cause*: Worn bearings. *Remedy*: Readjust (shim) the bearings or, better, replace the bearings with new ones.

Trouble: Brushes of repulsion-induction motors not in contact with commutator. *Cause*: Brushes too short, or brushes stuck in holders. *Remedy*: Renew all brushes, which should all be of the same length. Work brushes in holders to loosen them, or sandpaper brushes. Sandpaper commutator with No. 00 sandpaper (NOT emery paper).

Trouble: Consistently poor commutation. *Cause*: Brushes on a neutral point. *Remedy*: Shift the brushes to the side of "hard neutral" which gives the proper direction of rotation.

Trouble: Motor makes loud humming sound, but refuses to start. *Cause*: See directly above. Also, centrifugal switch of split-phase and of certain capacitor and repulsion-induction motors not functioning. Starting winding burned out, starting resistor open, capacitor shorted, or armature windings of repulsion types burned out. *Remedy*: Repair, adjust, and clean governor and centrifugal switch. Test starting winding of stator or repulsion-induction armature coils, replacing burned-out coils or rewinding same. Test starting resistor. Test capacitor with a D.C. testing outfit. Replace any defective components.

12. MOTOR RUNS BACKWARD

Trouble: Initial, or starting, torque turns rotor in wrong direction. *Cause*: In the case of repulsion-induction motors, brushes have been shifted to the wrong side of "hard neutral." *Remedy*: Loosen set screws holding brush-holder rocker and shift rocker to the correct side of the neutral point.

Warners' 27 Months to Divorce in U. S. Consent Decree

Warner Brothers has 27 months in which to divorce production-distribution from exhibition and to form two new companies, and up to two years in which to dispose of a maximum of approximately 80 of its theaters, under the terms of a consent degree with the U. S. government which concludes the 12-year anti-trust suit against the film company.

Highlights of the decree, patterned closely after the recent Paramount settlement with Uncle Sam, are:

Jan. 4, 1951, the Effective Date

The present Warner Brothers organization will be recast into separate production, distribution and theater companies within 27 months from Jan. 4, 1951.

Disposal of from 55 to 80 theaters is required, depending upon the number of competitive theaters playing first-run product on a regular basis in Warner towns and cities.

The three Warner Brothers and their families must dispose of their holdings in one or the other of the new companies within 27 months, or put them under control of a U. S. court-appointed trustee.

Trade practice restraints in the distribution of films—franchises, pooling deals, profit-sharing leases, etc.—are imposed.

CURRENT WITHOUT CONDUCTORS: When we think of electric current or electrons in motion, we customerily associate the current with some confining medium or transporting path, as, for example, a wire: a commonplace condition in electrical circuitry, yet not necessarily a "must" condition. In other words, it is not necessary that a metallic conducting path be present in order that electrons flow in a directed path and constitute electron current.

The operation of a vacuum tube demonstrates that a metallic conducting path is not essential: the grid, plate, and screen current within the tube advance through these effects inside of many vacuum-tube devices.

For example, an important attribute of the electron in motion is a magnetic field which surrounds the moving charge. Seldom do we pay any heed to this phenomenon in a high-vacuum rectifier tube, in an amplifier tube, or in an oscillator tube.

Admittedly, the movement of electrons through such devices is not in the form of a concentrated beam; if it were so, there might possibly be a remote association with a similar current through a wire. In the case of the cathode-ray tube, however, the electrons are confined into a narrow path; therefore, there is a that case because the ordinary manner of application of such tubes does not require recognition of this field. In the cathode-ray tube, not only does the magnetic field demand recognition, but it also is put to good use.

Stationary Charges

Not all of our dealing with electrons in connection with the operation of the cathode-ray tube are restricted to charges *in motion*—that is *dynamic* electricity. A good deal of what takes place within the cathode-ray tube is the result of the behavior of electrons *at rest*, of the positive charge at rest.

While it is true that we cannot create

The Cathode-Ray Tube: Basic Data

By JOHN F. RIDER and SEYMOUR D. USLAN

II. Electrostatic Deflection and Focusing

Second of a series*, this installment relates to the basic theory anent electrostatic action—data with which all professional projectionists should be familiar if they hope to cope with the ever-increasing complexities of electronically-controlled systems. Originally appearing in *Encyclopedia on Cathode-Ray Oscilloscopes and Their Uses*, these data are presented here through the gracious cooperation of John F. Rider, publisher of the massive (982-page) aforementioned authoritative work.**

"space" without benefit of conducting paths. The physical conducting paths appear at the elements and the circuits connected to the elements. The cathode-ray tube is another example of elecron flow through space.

These references to conductorless paths for current should not be construed as implying that a so-called open circuit is an operative system. Direct electron flow through space occurs only under proper conditions. Here, we are concerned solely with electron currents identified as conduction currents when they advance through wires; and we take for granted that wire circuits as paths are complete in every respect. We raise this point because the properties of electron currents as associated with wire conducting systems are applicable to like currents which are traveling through space.

Influence of Magnetic Field

We speak freely about vacuum-tube currents as being electrons in motion, but we seldom think of them as having the properties of current in a wire because we have no occasion to consider closer similarity between a stream of electrons moving through a wire and one advancing through this tube.

But it is not this similarity which forces us to stress the condition. Instead, it is that the electron stream within the cathode-ray tube not only possesses every propery of an electron current, especially the associated magnetic field, but also that the operation of the tube depends in part upon several phenomena which are tied-in with the magnetic field.

Electromagnetic focusing would be impossible without the magnetic attribute of the electron beam. The same, is true, of course, as far as electromagnetic deflection is concerned.

The absence of a concentration of electrons in a vacuum tube does not remove the electron stream from the conditions described as the basic laws of electricity and magnetism as applied to electric current—those conditions which are, of necessity, associated with the beam of electrons in the cathode-ray tube. Both are governed by identical law; it is just that these laws are of more immediate interest in the cathode-ray tube than in the ordinary vacuum tube.

Electrons advancing through a conventional vacuum tube are surrounded by a magnetic field, but it is unimportant in a positively-charged plate without first making electrons move away from that plate, leaving a residual net positive charge, we ordinarily ignore this transient motion of the electron. Conditions are considered only after the electron has come to rest somewhere else, where it sets up a negatively-charged surface.

If these statements remind you of "charged" bodies of surfaces, the basis of operation of the conventional vacuum tube wherein the elements act as charged surfaces, or even the principle of operation of a capacitor, your thinking is along correct lines.

Many of the performance capabilities of the cathode-ray tube stem from the creation of a "charged" state in some of the components which are part of its structure. The electrostatic fields and lines of force existing between these charged surfaces account for such actions as electrostatic focusing and deflection, because they determine *the paths* of electrons which pass under their influence.

Taking into account the properties of current and the fields between charged surfaces, it is evident that the basis of focusing and deflection is the establishment of *certain paths* for the emitted electrons and the beam by these phenomena. A review of the basic principles of these actions is essential. This can be done most easily by grouping the actions into electrostatics and magnetics, and discussing each separately—limited, of course, to those subjects within each group which are most directly associated with the title of this text.

Electric Fields and Lines of Force

It is a basic law of physics that unlike charges attract, and that like charges repel, each the other. Originally, when it was noted that bodies bearing charges

* The first installment appeared in IP for Dec., 1950, p. 28.
** 480 Canal St., New York 13, N. Y.

reacted in a certain manner upon each other, the general approach was that some sort of "action at a distance" was taking place. Among the early investigators, Faraday was a strong objector to this philosophy. Eventually he conceived the idea that something existed *between* the bodies which displayed attraction and repulsion for each other. The result was the concept of electric fields and lines of force as being in the space between the objects.

Graphical presentations of the electric field and the lines of force are strictly mental devices, to assist in visualizing certain phenomena. Sometimes it is convenient to think of the field lines or the lines of force as having certain physical properties; but these properties are only explanations of *what* happens, not the *cause*.

By accepting these concepts as a working tool without trying to demonstrate validity, it will be easier to comprehend the subject of fields, and in particular of electron lenses.

By an electrostatic field or electric field, the physicist means a special condition of space around every elemental charge *of either polarity*. By the special condition of space, the physicist means that energy, attributable to the charge, exists around it. Moreover, this energy is capable of exerting a force upon another charge.

The Vital 'Field of Energy'

Thus, every elemental charge, whether isolated in space or resting upon the surface of a body, is inseparably associated with an electrostatic field, which may be called a *field of energy*. Or, if we examine the condition from the viewpoint of the force which it may exert upon *another* charge, then the electrostatic or electric field is a *field of force*.

Since the field is one of energy or force, neither of which is a substance, the field is invisible, detectable only by its *effects*. Such effects are the forces which the field is capable of exerting upon something susceptible to it, and such a "something" is *another* charge or charges.

Now, recalling that every elemental charge has a field of its own, and placing a charge *A* within the field of another charge *B*: if we say that the field of *A* is capable of exerting a force upon charge *B*, we are stating only a part of the truth. In reality, charge *B* also has a field, so that the field of *A* is acting upon *B*, and the field of *B* is acting upon *A*.

When we speak about forces being present in a field and being the effect of the field, it must be remembered that this is a mutual condition involving all of the fields due to all of the charges. The manifestation of these forces is the action described by the basic laws of physics—the attraction between unlike charges and the repulsion between like charges.

Directed Quantity—a 'Vector'

Now, force not only has magnitude but is also a *directed* quantity—that is, it acts in a definite direction. (Such a quantity is called a *vector*.) If we say that a field is perceivable by its effects and these effects are forces, then the effects (forces) have *both* direction and magnitude. Here we have a clue to the means of representing the fields as a whole, or, rather, a means of illustrating the special condition of either the space around a charge, or the condition of space between charges.

What is done is to use lines which show the *direction of action* of the forces present in the field. We might describe these lines as being the paths of the force, or the paths over which the force

(*Continued on page* 25)

Cron-O-Matic Carbon Saver Utilizes New Principles

The Model U. N. Cron-O-Matic carbon-saver utilizes a completely new positive-carbon assembly and includes devices heretofore not employed with standard projection arclamps to effect an entirely automatic unit. Installation is extremely simple. All insulation being self-contained, the projectionist need only remove the old post and guide assembly, substitute the Cron-O-Matic, and discard the original insulation. Of universal design, the base casting is merely attached to the particular lamp for which it is intended.

The projectioinst sets the "top" carbon by means of the gauge furnished (Fig. 1), installs a carbon stub of any length—from 1¼ to 6 inches (regardless of the number of minutes the film is to be projected), swings the carriage back to the operating position, closes the lamphouse door—and operates as usual.

The "swing-out" of the carbon head has been designed for quicker cooling of the carbons as well as for convenience in re-trimming. No drilling of carbons, pins or sleeves is required, nor is it necessary to measure the stub against the running time.

Precise Alignment Assured

Under any circumstances, the stub is set back on the guide rest, ready for striking. The stub is in *exact* alignment with the negative: this is accomplished by raising or lowering the entire assembly and by lateral adjustment made possible by an eccentric.

Figure 2 illustrates how the stub has been consumed to the point where the tail-flame of the arc burns upward and onto the "top" carbon, preheating it to the same temperature as the stub. The carbon head, constructed of heat-resisting, non-magnetic alloy, is not damaged by the flame and has no effect upon the original setting of the permanent magnet.

In Fig. 3 is shown how the stub has dropped down out of the path of the now-burning "top" carbon. This drop is accomplished instantaneously due to a trip-spring inserted into the rear of the pivot action post. The "top" carbon will burn for 22 minutes at normal amperage for the given size used, making it impossible to run out of carbon on any full double reel of film.

Figure 4 shows the condition which exists after the "top" carbon has burned for 22 minutes at 65 amperes (8-mm carbons). It will be noted that the extension arm drops harmlessly downward out of the way of the reflector.

The Cron-O-Matic carbon-saver is sold through theatre equipment supply houses everywhere. Detailed descriptive literature will be sent free to anyone upon request to the manufacturer, Payne Products, 2454 W. Stadium Boulevard, Ann Arbor, Mich.

FIG. 1

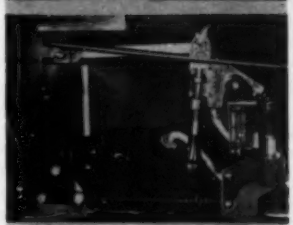

FIG. 2

FIG. 3

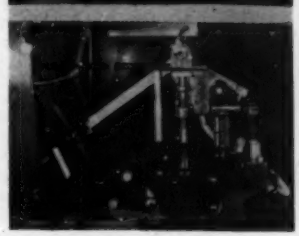

FIG. 4

IN THE SPOTLIGHT

By *HARRY SHERMAN*

ONE cannot read the recent government wage-price "freeze" order without experiencing mixed feelings of relief at some sort of action after weary months of delay and a "so-what-the-Hell" attitude mindful of the days of World War II in terms of too little, too late.

We motion picture people still have a potent publicity outlet *via* the newsreels, personal appearances of stars, charity sponsorships, collections, *etc.*—in short, anything smacking of glamour in terms of Podunk and all way stations to eject the stuffing from the soft cushions which soothe the Washington crowd into thinking that they can get away with anything.

Wage control without price control—bread, clothing, medicine, doctors' bills, and the thousand and one things necessary for the mere business of living—all these add up to the ultimate in governmental stalling and an appeal for votes come 1952 which will be overwhelmingly repudiated by the working men and women of America.

Wage control? Yes . . . but coupled with a control of the price structure that will enable the average JOE AMERICA to live and walk the streets of his native land in a manner befitting one who, we are told, is privileged (?) to vote for those who control his destiny by sheer weight of executive office.

No wage controls without price controls—that's our stand.

• Ernie Lang, recording-secretary for New York Local 306, recently notified the membership that the Local's Pension and Welfare Plan had been approved and put into effect. (See IP for Oct. 1950, p. 19.) This plan, which affects members working in major circuit theaters, Broadway houses, downtown Brooklyn theatres, and many of the independent houses, automatically reduces the union dues, and eliminates any future assessments for old-age pension and death benefits. For example, prior to the inauguration of the new Pension and Welfare Plan, the union dues for the present quarter would have been $42.80, as compared with $19.25 which is now payable.

All members of the Local, retiring after January 17, 1951, will receive a weekly pension of $30 (an increase of $9 per week over the previous pension allowance), which is independent of any government pension or Social Security allowance he may be entitled to.

In lieu of a wage increase paid direct to Local 306 members, the aforementioned theaters have agreed to contribute 5% of the men's basic wage scale to the Local's Welfare Fund. Payments for hospitalization and medical care for the members and their wives will be made from this fund.

Since negotiations for this plan were started several months ago, it will not be affected by the recent government wage-freeze order.

• Bill Kunzmann, convention vice-president for the SMPTE, advised us that the next meeting of the Society will be held at the Hotel Statler, New York City, April 30-May 4 next. We hope that the Society will justify its bid for projectionist members by devoting at least one session to matters of interest to the projection craft.

• As an example of what we consider smart public relations, we point to the line followed by Local 586, Nebraska (Grand Island, Columbus, Norfolk, Hastings, and York), in effecting a more harmonious relationship between the Local and the various civic, educational, and religious organizations in its jurisdiction. In trying to overcome the many deep-seated and unfair prejudices against labor unions, the members of Local 586 gave generously of their time and experience to these organizations whenever they put on a show. Eventually, a barrier of many-years' standing was completely broken down, and today Local 586 has their confidence and respect. Today, whenever an entertainment is planned, the Local furnishes the needed men, at regular pay.

Many thanks to Conrad Krieger, secretary of the Local, for forwarding this information—which might be emulated with profit by other Locals.

• A representative gathering turned out to witness the installation of the new officers of the 25-30 Club at the regular January meeting. Harry Mackler, president (member of New York Local 306); Edward Dougherty, vice-president (Local 384, Hudson County, N. J.), and Charles Eichhorn, trustee (Local 306), are the only new officers for 1951. Holdovers are Morris Klapholz, secretary, and Ben Stern, financial secretary-treasurer. Morris J. Rotker, past-president of the Club, presided at the ceremonies.

Among the invited guests were Admiral R. B. Tompkins, president, and Arthur Meyer, vice-president and general sales manager, International Projector Corp.; Walter E. Green, president, National Theatre Supply Co.; Allen G. Smith, New York City branch manager for NTS, and Barney Passman, chief engineer at the IPC plant in Bloomfield, N. J.

• Realizing the advantages to its younger members of a more thorough grounding in the duties of a stagehand, officials of Local 366, Westchester County, N. Y., are sponsoring a course in back-stage activities at Hunter College, New York City. This course is conducted by a member of the Local and classes are held twice weekly. Nat Storch, president, and Joe Monaco, business representative for the Local, have long cher-

ished this idea; now that it has been realized, we hope it will be tremendously successful.

• Anonymous letters, always the refuge of the cowardly and the bane of our existence. Most of us have at some time or other been the recipient of an anonymous letter or two attacking either our own or some other person's character. The writers of such letters hide behind the cloak of anonymity either because they cannot substantiate their charges or because they just haven't the guts to back them up.

As a member of one of the larger Local Unions in the Alliance, we have received many unsigned scurrilous letters, pamphlets, *etc.*, attacking the Local administration and individual members. These were generally signed "Anonymous," "The Fair Deal Committee," "Unemployed Operators Committee," "Independent Theater Operators Committee," and many other phony-sounding committee names, too numerous to mention.

It has long been our contention that such "committees" usually are nonexistent—that they are merely a dodge behind which a few disgruntled members try to hide their identities. We believe that when members are dissatisfied with conditions existing in their Local and feel that they have legitimate cause for complaint, or wish to bring charges against any of its officers, they should air their grievances through the channels that are open to them and not hide behind faked committee names.

This reminds us of a comment made by Henry Ward Beecher when he received a letter which contained one word: "Fool." He said, "I have received many unsigned letters of criticism, but this is the first in which the writer signed his name but forgot to write the letter." This leaves nothing more to be said.

• The recent death of Emmett Carter, Sr., business representative of Local 587, Longview-Marshall, Texas, ended a career of many years service to the Local. Several months ago the Local awarded Carter a gold button for 37 years' loyal service.

• Wedding bells rang again for Mike Berkowitz, veteran member of New York Local 306, and his wife, Anna, when they celebrated their 50th wedding anniversary last month at the Grand Street Boys Clubhouse in New York City. Several hundred guests witnessed the "golden" ceremony, which was very beautiful and touching. Mike was as nervous as a young bridegroom; Anna was her usual composed self—naturally.

Dinner and dancing until the wee hours wound up one of the most delightful evenings we have had in a long time. The entire affair was arranged and planned by Mike's son, Milton, chief projectionist at the Capitol Theater, famed Broadway house.

25 Years Ago—February, 1926

• The IA Executive Board unanimously elected Barney Ryan, member of Brooklyn Local No. 4, a member of the board of trustees, succeeding William Harrer, who was elected 7th IA vice-president. . . . President Bill Canavan's plan to publish a book of all IA convention proceedings from the inception of the organization to the present date was endorsed by the Executive Board. Order blanks were to be sent out to all Local Unions to determine the feasibility of such a project. . . . The nomination of George Curran, member of Boston Local 182, as a candidate for the office of sheriff of Suffolk County, Mass., was endorsed by the IA Executive Board, which urged all Local Unions in Suffolk County to get behind their fraternal brother and help elect him to office. . . . The IA donated $1000 to the Striking Anthracite Miners' Fund in response to an appeal by the AF of L Executive Council. . . . The General Executive Board, by unanimous vote, decided that "in the event a member be denied the privilege of working in the jurisdiction of the Local Union with which he is affiliated for any reason whatsoever, that member would not be permitted to accept employment in the jurisdiction of a sister Local Union, and his traveling privileges will be suspended until such time as his Local Union again grants him the privilege of working." . . . Malcolm Grow was expelled from membership in Local No. 638, Carbon County, Penna., for refusing to obey the official road call effective against the Park Theater in Lehighton, Penna. . . . The appeal before the IA Executive Board of Jack Seraphine, member of New York Local No. 306, against the Local's action in refusing him the privilege of running for office for membership on its Executive Board was denied. The Local alleged that Seraphine did not pay his dues within the prescribed period.

Report on IA-IP Amateur Radio Contest

By AMOS KANAGA (W6BAA)

SHORT-WAVE radio is sometimes like the fair sex: it can be gracious and generous; then again, it can be a stinker. And the IA-IP amateur radio contest week, as far as weather conditions were concerned, was a "stinker." However, on the basis of reports received to date and the many more expected, it would seem that the boys did pretty well for themselves.

The contest did not approach other such national events in terms of thousands of participants, but considering the comparatively short time in which IA national listings have been published, we did pretty well for ourselves.

Many of the boys worked their first IA contact; others had several lined up. Whenever the band opened up, especially on 10 meters, there were IA men on the air. Most of them hovered around the 28,850 frequency and passed the word along when a new IA station was worked or heard. One West Coast station worked *eight in a row*—then didn't hear any IA men for three days! After midnight, 75 meters was fairly active.

IP Listing Continues to Grow

Many new calls will be added to our list as a result of this contest, since many of our boys now look to the pages of IP for the current listing of IA radio men.

An outstanding thing about this contest, remarked by many of our fellows, was that there was not the usual haste displayed in making contacts, as in other contests. There was more real fraternization, the boys made schedules to QSO again, and they met a lot of IA men they never knew were around on the air.

IMPORTANT: please send in a copy of your contest log, even if you only worked one IA man (and that is all several did); that station may be one that is not now on our list. When we put them all together, we'll really have something. Our list grew because every one of you took time out to let us know of another IA man who was a radio amateur. That's FB and real spirit!

We tried our best to make the deadline for this issue, but all scores were not received in time. Fellows, we must have your log to cross-check, even if you worked only one IA brother. So, shoot it in to me pronto at 262 Westland Ave., San Mateo, Calif. Complete scores, and the contest winners, will be announced in the next (March) issue of IP—plus, of course, the very latest listing.

Many thanks—and 73.

RCA Eng. Products Personnel Changes

Theodore A. Smith, for the past five years head of sales for RCA Engineering Products, has been named assistant general manager of the department. He succeeds W. W. Watts, who is on a leave of absence for service with the NPA in Washington.

Simultaneously, A. R. Hopkins was named general sales manager of the department, while Barton Kreuzer was appointed general product manager.

Report on First Month's Phonevision Chicago Test

THE Tv topic of prime interest to film people during the past month was the report issued by Eugene F. McDonald, Jr., president of Zenith Radio, on that company's Phonevision tests over a four-week period among 300 selected families in the Chicago area. In a letter to distributors who supplied the films for the tests, McDonald declared that the operation in its first month drew 26% of the "total possible attendance." No mention was made of the obvious novelty appeal of the operation.

McDonald cited figures indicating an over-all average of 30% of the possible audience. The ten lowest-grossing features offered drew an average of 22%, and, the Zenith head declared, relatively few feature pictures produced in the last 20 years have played to that large a percentage of the possible theater audience on their first showing.

Films Two Years or More Old

Zenith is using films two or more years old, which have played out their theatrical dates.

Average attendance of those participating in the test was 3.1 times in the first week of the test, dropping to 1.9 for the second and third, and 1.7 for the fourth. Disregarding the initial week, average for the next three was 1.8 times per week per family, McDonald points out.

Projecting this against the 10 million receivers presently in use would indicate a producer's income of $468,000,000 annually, on the basis of 50% of the $1 fee charged in the Chicago test. To a large extent, McDonald declared, this would be supplemental to income producers would continue to receive from theaters.

Cites Results as 'Fabulous'

"These first four weeks' results on Phonevision are fabulous," McDonald emphasized. "even if you cut them in two or in four. And you must remember that this test is handicapped to some extent by the age of the pictures. All of these pictures played in theaters before the majority of our test families owned television receivers, most of them during the high-water period of theater attendance.

"We have secured phenomenal results by tapping an audience that did not see these pictures in the theater. I think it is reasonable to assume that many of these who did not buy the pictures on Phonevision, refrained because they had already seen them. Can you imagine, then, how much more startling our results would be if we were presenting new pictures that none of our families have previously seen?"

First-Time Viewing by Many

In another summary of postcard reports from Phonevision subscribers, McDonald pointed out that, except for a few great classics, four out of five are seeing the pictures they purchase for the first time, "in spite of the fact that each of these pictures has long since completed its theater runs, and that some had been reissued."

"It is self-evident," the Zenith president said, "that with Phonevision we are reaching that vast segment of our population that never were regular theater-goers, and that in reaching this new audience we are adding countless millions of dollars to the value of the old features you have in your vaults. It is not beyond the realm of possibility that many of your older pictures will earn more for you on reissue by Phonevision than they have earned to date in theater showings."

Expand Use of Tv Channels

Experiments by 20th Century-Fox in theater Tv relaying the past two years indicate that cross-polarization may well lead to greater use of certain Tv channels.

These experiments, conducted in New York on the 6800-7050 mc band, indicate that programs can originate at two different points on the same channel and be received at a distribution point without cross-channel interference. While the experiments were made primarily with theater Tv in mind, the report indicates that cross-polarization will increase the use of all Tv channels.

The experiments disclosed that programs could originate at two different points, be fed to a major distribution point, then relayed to a second distribution point without interference, although only one channel was used.

AF of M Ultimatum to Tv Nets

Further difficulty for Tv broadcasters is the announcement by the American Federation of Musicians that the networks may use on Tv only those films "expressly authorized between the AF of M and producers (film) or others having interest in such film." If this ban persists, Tv stations may be in a bad way for film fare.

AF of M will permit use of film reproduction of a "live" telecast by affiliated network *at the same time show is given*, but reproduction may not be given more than one time; but in the event that it is, the following payments will be due: (1) a repeat fee must be paid to the musicians, and (2) payment must be made to the Music Performance Trust Fund equal to 5% of the "gross time charges."

Du Pont Price Tilt, Curtailment

Simultaneous with the issuance of new price list which shows increases averaging 11½% for both negative and positive motion picture film (attributed to increased labor and material costs) Du Pont notified its customers that it was curtailing its orders by 25%. Action was taken it was explained, because of commitments to produce an increased supply of X-ray film for the armed forces and others.

Hardest hit by this curtailment of motion picture stock will be the newsreels and small laboratories, representatives of which are making strenuous efforts to have the cutback modified, at least.

Sample price increases on Du Pont stock per 1000 linear feet: 35-mm safety negative, from $43.76 to $49.21; release positive safety film, from $14.80 to $16.22.

4-Inch Lens Now Standard on All Century Projectors

Century Projector Corp. announces that the latest and most modern 4-inch diameter lens mounts are now standard equipment in Century Model C single-shutter and Model CC double-shutter projectors, on both the standard as well as the water-cooled models. This change continues the Century policy of keeping pace with the latest industry developments. Although 4-inch diameter lenses are now available only in the longer focal lengths, there are indications that the trend toward larger diameter lenses make it desirable at this time to standardize on the larger lens mounts for all projection equipment.

Confirm Nate Golden as NPA Film-Photo Director

Nathan D. Golden has been officially confirmed as director of the Motion Picture-Photo Products Division of the NPA. Golden formerly headed the Motion Picture Division of the Dept. of Commerce. During World War II he was consultant to the Production Board and to the Office of Coordinator for Inter-American Affairs. He also served as consultant to the Golden Gate International Exposition, and to the American group which considered world tariffs and trade in France in 1949.

Long, Varied Film Career

Golden has long maintained close contact with the projection groups in the film industry, following his early days as a member of IA Local 160 of Cleveland, of which organization he is a life member. He received the first gold medal award of the Projection Advisory Council.

A veteran of World War I, Golden entered U. S. service in 1926. He is a graduate of Washington College of Law, American University; past commander of the D. C., V. of F. Wars as well as of the Legion Post, National Press Club; fellow of the SMPTE, member of Projection Advisory Council, and chairman of the Heart Committee, Variety Clubs.

NEWS PROJECTIONS

WHOLLY aside from present construction curbs, theater building should be stopped completely for five years as a "breather" and to check overseating which is rampant, says Abram Myers, general counsel for Allied States exhib group. . . . Paramount plans to put 52 features in work within the next 24 months, Tv notwithstanding. . . . Theater construction and alterations in Canada last year cost $6 million, bringing the past five-years' total to over $33 millions. . . . Loew's has been granted extra time to March 31 next to file its exhibition-production divorcement plan with the Dept. of Justice. . . . More than 97% of U. S. theaters sell candy, 95% sell popcorn, and 79% sell soft drinks. Some 86% have refreshment stands, while 47% use coin machines, meaning some have both. . . . Technicolor announced that it plans to process 103 forthcoming productions either set for release, in production, or in preparation. Biggest Technicolor program ever, probably in response to insistent exhibitor demand.

- - -

National exhibitor groups still fearful that the present high 20% ticket tax will be boosted during current defense emergency; although in-the-know Washington sources insist there will be no upward tilt. . . . National Collegiate Athletic Assoc. Tv committee came out flatfootedly for a ban on home telecasts of football games, citing a box-office drop this past season. Committee would like to make an exclusive deal direct with theaters, if enough houses would install Tv units. . . . Paramount has announced the purchase for retirement of 251,000 shares of its own common stock on the N. Y. Stock Exchange, *at the pegged price* of $21.50 a share. . . . RKO Theaters in New York area have concluded a 13-week deal with NBC Tv outlet to promote former's attractions and "Let's Go Out to The Movies" campaign. First such deal by a major circuit. . . . Permission granted to RCA to appeal recent Chicago court decision anent color Tv (which favored CBS noncompatible system approved by the FCC) is largely academic in view of manufacturing restrictions which will effectively bar color Tv progress for several years. . . . Better pictures plus increased defense plant earnings are cited for recent upswing in box-office take, especially in Mid-West and South. . . . Quote from Julian Brylawski of Metropolitan Theater Owners of Washington, D. C., on possible theater Tv installations: "We cannot *sell* what they (standard Tv programs) are *giving away*, no matter how

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inferior their product is." . . . Schine Theaters, loser in a Government anti-trust suit, has put 28 houses in New York, Maryland, Ohio and Kentucky on the block, ranging from the 394-seat Corbin, Ky., leasehold for $7,500 to the 1381-seat Madison in Rochester, N. Y., for $550,000.

Arctic Blanch Screen Surface

High reflectivity and a near-perfect diffusion of light over the entire surface are the primary requirements for an efficient screen in a drive-in theater. An additional consideration is the ability of the screen surfacing medium to withstand the rigors of all types of weather through a long operating season.

This is the opinion of Ken Caldwell, president of National Theater Screen Refinishing Co., Buffalo, N. Y., and a member of IA Local 233, following an intensive survey of scores of drive-in screen surfaces.

Ordinary flat paint will enable a high degree of reflectivity, says Ken, but it contains little oil and thus cannot withstand weather abuse. The trick may be accomplished, however, by the proper combining of certain materials which fulfill all requirements. Ken asserts he has turned this trick with his Arctic Blanch refinishing paint, already used in several hundred drive-ins.

Arctic Blanch finish permits high reflectivity, fine diffusion of light without glaring "hot spots," and stands up under all weather conditions. Full details of this product may be had by writing direct to NTSR Co., at 129 Zenner St., Buffalo 11, N. Y.

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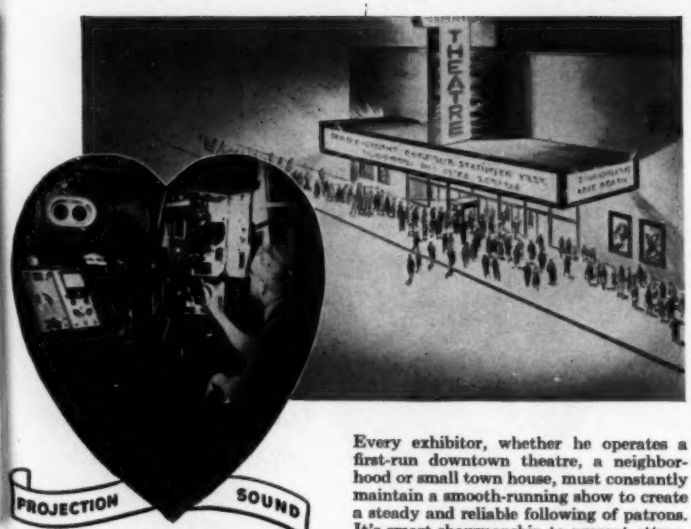

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LOCAL 291, GRAND RAPIDS, MICH.

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LOCAL 310, ATLANTIC CITY, N. J.

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CATHODE-RAY TUBE DATA

(*Continued from page* 19)

would be exerted; if the force is applied to move a charge, the motion of the charge would be along such a line. Hence the physicist's artifice of *lines of force* as the pattern of the electrostatic field. This makes sense and is a very convenient method of presentation because it does inform about the *condition* of the space.

Admittedly, such a direction line alone is not all the information about the forces present within a field, because it lacks data relative to the *magnitude* of the

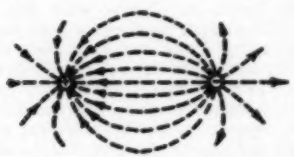

FIG. 5. Representation of the electrostatic field between two unlike charges.

force. However, if we are interested only in the general pattern of the field, and not in the *exact constants* of a *specific* field, we can do without the magnitudes of force at different points in the field.

Such actually is the case: the pattern of the electrostatic field between two unlike and between two like charges is of much more value to us than the *actual distribution* of forces. This is so because our object now is the presentation of information about the *purpose* of the lines of force and their *behavior*, rather than the actual magnitudes. So the stage is set for the picturization of an electrostatic field and lines of force.

The Field Between Unlike Charges

In Fig. 5 is shown the electrostatic field between two unlike charges. These need not be two elemental charges of unlike sign; they could just as readily be *accumulations* of unlike charges—all of *one* sign in one group distributed around the surface of a sphere, and all of *opposite* sign similarly distributed on the surface of another sphere. The general nature of the field will be the same for both of these conditions, although it must be said that such a pattern will not hold for all configurations of the body which mounts the charges.

When the shape of the field sources is spherical and the charges are unlike, the pattern of the field is as shown in Fig. 5. A change in shape of a group of charges will cause a different type of field. Meanwhile, it is possible to develop information about the behavior of the lines of force using this elemental field pattern, because the *manner* in which the lines of force *behave* is fundamental and not subject to specific configuration either of the field source or the field itself.

Many interesting observations may be made about such a field in terms of the lines of force. For example, some lines of force are shown joining the two unlike charges which we shall assume to be separated by a certain distance. The actual dimension of this distance is unimportant. Other lines are shown incomplete. This, however, is purely a matter of limitations in illustrating, because every line of force between two charges join these two charges. Therefore, if you can visualize such a thing, the lines of

Kodak's 39th Annual Wage Dividend

Eastman Kodak directors have voted an employe wage dividend of an estimated $18,000,000 for about 45,000 Kodak men and women in the United States. Eligible employes will receive $27.50 for each $1,000 earned at Kodak during 1946 through 1950. To be paid March 9, 1951, the wage dividend will be the 39th payment under the plan.

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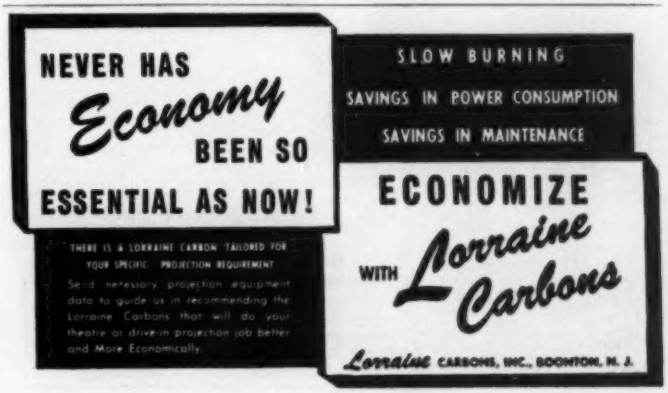
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force issue from each charge in all directions and join the charges.

Spacing of Lines of Force

The two charges in Fig. 5 are shown relatively close to each other. Such, however, need not be the case: the unlike charges can be far apart without in any way changing the condition that lines of force from a negative charge will terminate on a positive charge, or *vice versa*. Theoretically, the amount of separation of the unlike charges is of no consequence.

Then there is the matter of the space between the lines of force. This, too, is a limitation in illustrating. Actually there is no space between them; all the area, in all directions, is filled with lines of force. In drawing the field, we select certain lines only as being representative, and show them.

As to the direction of the field, shown by the arrowheads, it is the direction in which the force would be exerted *along the line of force* in accordance with a certain convention. This requires some elaboration.

Two conventions exist for the direction of an electrostatic field. One frequently-used convention assumes such direction of the field as would be indicated if a test charge of positive polarity were placed into the field. The other convention, used herein, assumes such direction of the field as would be indicated if the test charge placed into the field were of negative sign. Our preference for this convention is based on the fact that the electrostatic fields in the cathode-ray tube act on the electron, which has a negative charge; therefore, we avoid confusion by considering that direction which conforms most closely to the final analysis of cathode-ray operation.

Accordingly, the direction-arrows point away from the negative charge and toward the positive charge, and show the direction in which an electron would move when under the influence of the field. In this connection, we might mention that the field shown in Fig. 5 does not require the negative charge to advance to the positive charge. It is possible to imagine these two charges as being fixed in their respective positions, in which case conditions would remain constant and an electrostatic field of a certain direction, which *could* cause a certain motion on the part of an electron placed within the field, would be effective.

Behavior of the Lines of Force

Continuing with our discussion of the field between two unlike charges, as shown in Fig. 5, several very important comments must yet be made. Perhaps, from the viewpoint of utility, these are more important than any made so far.

We mentioned earlier that the effect of the field was the application of forces to those things which were susceptible to such forces. Let us consider the basic law which states that unlike charges are attracted to each oher. Such attraction often involves physical motion and, according to our convention, it would be a motion of the electron.

Is such motion a function of the charges themselves, that is, their presence? Or, put differently, do the charges move of their own volition because they are of unlike polarity?

According to the theory, the answer is negative. It is true that the polarity of the charges determines the field, but the effect of the field as interpreted in the motion of the charges is due to the *behavior* of the lines of force. As stated earlier, these lines are aids to visualizing what actually does happen, and have no independent existence outside of the imagination. Since they are imaginary,

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we may assign any properties we choose to help describe what actually happens.

One such property is that of lengthwise contraction: we assume that lines of

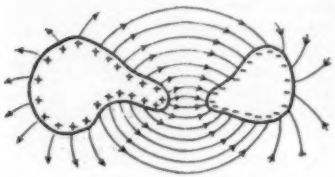

FIG. 6. Distribution of electrostatic lines of charges on an irregularly-shaped body.

force tend to shrink along their length. For example, a line extending from a positive charge to an electron, in shrinking, would draw the electron toward the charge. If the electrons were carried further away from the positive charge, the line of force would be stretched; a mechanical force would be required to do this. Given the opportunity, as determined by the mobility of the charges, the electric lines of force between the two charges will bring the charges together so as to satisfy the fundamental condition of minimum length of the line of force.

Harnessing Energy

It is because of this, as well as a few other conditions, that a comparison is made between the behavior of such lines of force and that of stretched rubber bands. Of course, there are limits to the application of this analogy, but it is a reasonable one when we visualize the line of force as possessing energy which can be put to use, just as the stretched rubber band possesses energy which can be put to work. Most certainly the tendency of the stretched rubber band is to shorten itself, and in so doing, to do work.

The same can be said about the electric line of force. Given the opportunity to contract, the energy present along the line of force will be transformed into other forms of energy—perhaps kinetic energy applied to the electron so as to get it to move, or/and, of course, into heat. At any rate, the energy in the field, distributed along he lines of force, is capable of doing work during the time that the lines of force contract.

Another property of the lines of force is that lines active in the same direction appear to repel one another laterally. This accounts for the curvature of the lines of force which join two charges at points other than on the straight-line axis between the charges.

Effect of 'Repulsive Force'

The line of force along the axis is straight because the amount of repulsion, from other lines laterally positioned, is the same on all sides—in other words, the forces are symmetrical. However, at distances from the axis the lines of force curve outward because of the greater amount of repulsive force originating from the direction of the axis and the less repulsive force originating from the outer side of the force line. Nevertheless, spaces still do not exist between the lines of force: the lines simply curve outward instead of being straight.

This property of the lines of force between two unlike charges may not have much bearing upon the *behavior* of such charges. Being subject to attractive forces, it is the *shortening* of the line of force along its length which is the paramount action. However, the lateral repulsion between the lines of force with like direction is very important in the behavior of like charges.

[NOTE: A comprehensive review of this series of articles over-all will be available to those readers who preserve the issues in which each installment appears, beginning with IP for Dec., 1950, and running in consecutive issues hereafter.—ED.]

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OPTICS OF ARCLAMPS

(*Continued from page 6*)

mum waste of light at the aperture spot.

The writer strongly suspects that an apospherical mirror designed for use with the ordinary H-I arc will be elliptical, like the orthodox mirror responsible for our oft-voiced complaints. There is, however, a very important difference.

Compared with the usual type of elliptical mirror, the curvature of the apospherical mirror will be "exaggerated," *i.e.*, the central zones will have a greater curvature than the regular type of elliptical mirror, and the outer zones will have less curvature.

An optical designer will at once recognize this mirror as an elliptical mirror having a greater "eccentricity" and a longer "major axis" than the orthodox lamp mirror. From still another point of view, it may be said that our apospherical mirror is a "parabolized" elliptical mirror, even though it is not a true parabolic mirror.

The success we hope to obtain with the apospherical mirror depends in a very large measure on the exact relation of arc-crater and aperture positions to the actual geometric foci of the ellipse. We will now break the rules of orthodox mirror optics and place the positive crater slightly beyond the focus which lies nearest the mirror, and permit the distant focus to fall where it may on the far side of the aperture. And no less important are the diameter of the positive crater and the luminosity gradient across its face. Both factors must be taken into account by the optical designer.

The calculations required in the designing of such a mirror are plenty tough—but not too tough for a competent optical designer. However, lacking this high degress of mathematical wizardry, we can do as well by the trial-and-error method, that is, making a number of apospherical mirrors of different degrees of approximately correct ellipticity and selecting the one which gives the screen results we desire.

The ideal apospherical mirror will produce a "spot" very much like that shown in *C* of Fig. 4; and the side-to-center distribution of light on the screen will lie between 90 and 95%, giving the appearance of perfect uniformity. Pleased as we may well be with this improvement, we soon discover other good reasons for praising our apospherical mirror.

Despite the fact that the crater of the positive carbon lies a trifle from the mirror than is the case with the ordinary lamp set-up, reducing very slightly the total amount of light picked up by the mirror, we find that the total light flux pouring from the lens of the projector is no less than with the most efficient orthodox elliptical mirror. This is because we can now employ a smaller, more sharply defined spot than before. The smaller the amount of light wasted on the cooling plate, the brighter will be the screen.

Uniform Screen Illumination

And this is not all! Because the "hot spot" has now been completely eliminated from the screen, minute accidental wanderings in the position of the positive crater do not show up on the screen—the crater would have to be away out of line to darken one side or corner of the screen. Yes, the screen is flooded by smooth, bright illumination all over its immense surface. No chance at all for one side of the picture to become brighter or dimmer than the other side due to slight movements of the positive carbon! Moreover, uniform illumination of the film in the aperture decreases the liklihood of embossing or blistering the center of the frames when high-powered arcs are used.

The outstanding peculiarity of the apospherical mirror in its proper application is its inability to form a true optical image of the "object" (arc crater). A pinpoint light source, for example, is focussed at the aperture as a ring of light with a comparatively dark center. A spherical cirror would give a fuzzy blob of light under these conditions; and an orthodox elliptical mirror would give a true point image. The apospherical mirror, therefore, distorts the image of the bright-centered H-I crater in such a way that a uniformly illuminated disc of light is formed at the aperture.

Readers of these lines may suspect that some degree of antispherical aberration can be produced by bringing a

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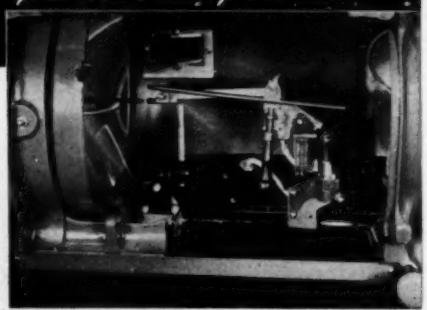

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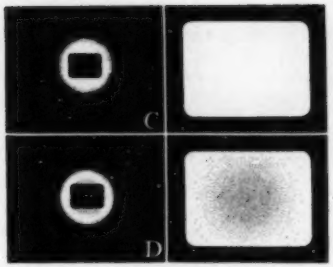

FIG. 4. The "spot" and resulting screen illumination produced by *C* a special elliptical mirror designed to produce the opposite of spherical aberration, and *D* a parabolic mirror used without a condensing lens. Only a mirror capable of counteracting the "hot spot" of the H-I crater can give the uniform screen illumination shown in *C*.

standard elliptical mirror (or the entire lamphouse) closer to the projection head, thus shortening the working distance. That is absolutely true. But because the ellipticity of the mirror remains unchanged, the amount of antispherical aberration which can be brought about in this way without producing undesirable side-effects is very limited.

These undesirable effects are decreased efficiency of the mirror, discoloration of the light, and a shadow spot in the middle of the screen. Besides, unlike the old L-I mirror lamps, which were comparative lysmall in overall size, and which were provided with sliding mirror supports, most H-I lamps, both rotating-positive and simplified, are constructed in such a way that optical corrections are impossible with them.

Side-to-Center Distribution

The foregoing paragraph may serve to explain why the writer has been unable to obtain anything better than an 80% side-to-center distribution with commercial H-I arc-lamps. Many of these lamps permit nothing better than 65 or 70% distribution, no matter how carefully they are set up.

Turning once more to Fig. 4: the panel marked *D* shows what happens if the eccentricity of the apospherical mirror is made too great. The antispherical aberration is so pronounced that the edges of the picture are actually brighter than the center area—a very undesirable condition.

The data from which panel *D* was sketched were obtained fro man experimental set-up utilizing a parobolic mirmor. A parabola is[a geometric figure obtained by slicing through a cone, keeping the cut paralle dto one of the sides of the cone. Unlike an ellipse, a parabola has one end open, and the sides never meet no matter how far they are extended.

A parabola has only one focus. When a point-source of light is placed at this focus, the rays are sent out from the mirror parallel to one another, a situation which permits them to snap their fingers at the inverse-square law.

A beam composed of truly parallel rays never weakens in intensity, not even if it travels a billion miles. In actual practice there is no such thing as a true point-source of light, because even the very smallest things in nature—protons, electron-waves, and single waves of gamma radiation—have appreciable size. Nevertheless, very small light sources used with parabolic mirrors produce beams which travel quite a distance before they finally weaken and give up. Examples are navy searchlights, airfield beacons, and locomotive headlights. The reflector of an automobile headlight is a parabolic mirror of short focal length.

If the source of light is placed slightly beyond the focus of the parabolic mirror, a "spot" is obtained, as in panel *D* of Fig. 4.

In motion picture work, the parabolic mirror was used in one of the Motiograph

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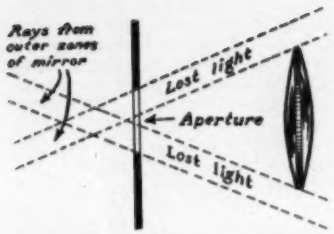

FIG. 5. Much of the light focused on the film by the outer zones of a large lamphouse mirror is lost because it overshoots the lens. The result is "hot-spot" projection and overheating of the aperture plate and film.

L-I lamps. The mirror threw the light forward in the light-cone of the lamphouse. The condenser converged them to a brilliant spot at the aperture.

Lamp manufacturers may well reconsider some of the "flexible" features of the older projector lamps—a smaller housing and a moveable mirror support. Most of the latest lamps, even those rated at 150 amperes, are too big in physical size. It is quite a problem to squeeze a pair of them into a small projection room. The same optical efficiency can be obtained with smaller mirrors located closer to the projector head. Of course, they must not be so small that they overheat, but there is little danger of that. Compared with some of the old-fashioned L1I vertical arcs which blazed away with awesome fury at 130 amps, the most powerful modern H-I arcs are cool indeed.

Greater optical flexibility in the design of H-I lamps has much to commend it to manufacturers. By making simple predetermined adustments in mirror and burner distances, various mirrors could be made available to supply the degree of light distribution most satisfactory to each particular proection installation.

A side-to-center distribution of 60% may be good enough for some drive-ins; 80% for other drive-ins and for extremely large indoor theatres, and 95% for small and medium-size indoor theatres and other operations demanding the best.

As We Were Saying . . .

Despite our numerous critics, we repeat: the appearance of uniform screen illumination cannot be obtained without uniformly illuminating the screen. No side-to-center distribution under the optimum 95% is acceptable where projection of the highest quality is desired.

It has been pointed out time and again in IP that the distribution of light on the screen is affected by the projection lens as well as by the optics of the arc lamp. A projection lens too small in diameter fails to intercept much of the light passing close by the edges of the aperture. and thus produces an objectionable fadeaway of light at the edges of the projected picture. All things being relative, it stands to reason that too large a lamp mirror produces the same bad effect.

Lenses having speeds of F:1.9 or F:2.0 are about as large as is practical, both from the standpoint of the optical designer and that of the projector manufacturer. Lenses of even these rapid speeds, .however, .are actually *overmatched* by the optics of almost every arclamp on the market.

A mirror *rated* at F:1.9, for example, represents an actual optical speed of approximately F:0.34. Calculation shows that it would require a lens-speed of F:1.36 to match such a mirror, if the projection lens has a focal length of 4 inches. Lenses as rapid as F:1.36 simply are not available.

Effect of Oversize Mirrors

Figure 5 shows how oversize mirrors heat up the aperture plate and the film without producing an equivalent increase in screen illumination. Much of the light coming from the edge zones of the mirror does not even hit the lens! But even though the rays from the top edge of the mirror and passing through the lower part of the aperture miss the lens, the rays from the same edge of the mirror passing through higher areas of the aperture do succeed in striking some part of the lens. The net effect is a hot-spot at the center of the screen and a fadeaway at the edges.

The apospherical mirror described previously, however, would go far to minimize this undesirable characteristic of large mirrors, and actually increase their efficiency as regards total screen lumens.

With such a mirror, the rays thrown forward at the top edge of the mirror are concentrated at the top of the aperture; rays rfom the bottom of the mirror at the bottom of the aperture. The "crossover" of rays shown in Fig. 5 is thus shifted toward the lens, minimizing the "spread" ofthe light, enabling the lens to receive much more of the light which passes through the film.

Lamps having extremely large mirrors working at comparatively short distances from the projector aperture may thus be expected to give hot-spot effects. Such lamps, however, actually do produce an extremely large volume of light for the amount of current burned; and their use is practically mandatory for drive-in theatres. In fact, some of the larger drive-ins could not well exist without such lamps.

The foregoing remarks, therefore, are applicable only to lamps designed expressly for use in small and medium-size indoor theatres, where light-distribution on the screen of better than 60 to 80% is desired.

[NOTE: The Ventarc mirror described in an article beginning on p. 24 of the December, 1950, issue of IP performs the same optical job as the "apospherical" mirror described in this article. It remains to be seen, however, which of the two mirrors works most efficiently, and with a minimum of edge-coloration of the picture.]

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